The Distribution of Landings of British Columbia Salmon in Relation to Size of the Commercial Fishing Fleet, 1967 - 1981. III. Sockeye Salmon

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TABLE OF CONTENTS

	Page
ABSTRACT	iv
INTRODUCTION	1
MATERIALS AND METHODS	1
RESULTS	3
GILLNET COMPONENT	3
SEINE COMPONENT	4
TROLL COMPONENT	5
DISCUSSION	6
ACKNOWLEDGMENTS	7
LITERATURE CITED	7
TABLES	9
FIGURES	21
APPENDIX A	25
APPENDIX B	41
APPENDIX C	57

ABSTRACT

Beacham, T. D. 1984. The distribution of landings of British Columbia salmon in relation to the size of the commercial fishing fleet, 1967-1981. III. Sockeye salmon. Can. Tech. Rep. Fish. Aquat. Sci. 1285: 71 p.

The distribution of landings of sockeye salmon in relation to the size of the commercial fishing fleet was investigated on an annual basis during 1967-1981. An average of 1855 gillnetters accounted for 90% of the total landings in any year. Fifty-six percent of the vessels participating in the gillnet fishery landed less than 1000 sockeye salmon annually. The top 50% of the vessels participating in the gillnet fishery accounted for 81% of the total annual landings. An average of 290 purse seiners accounted for 90% of the landings, and 41% of the seiners landed less than 2,000 pieces annually. The top 50% of the seiners accounted for 84% of the total annual landings. An average of 777 trollers accounted for 90% of the total annual landings of sockeye salmon. About 88% of all vessels participating in the troll fishery for sockeye salmon landed less than 400 pieces annually. The top 50% of the vessels that landed troll-caught sockeye salmon accounted for 94% of the total annual landings.

Key words: British Columbia, catch, exploitation, gillnet, seine, sockeye salmon, troll.

RÉSUMÉ

Beacham, T. D. 1984. The distribution of landings of British Columbia salmon in relation to the size of the commercial fishing fleet, 1967-1981. III. Sockeye salmon. Can. Tech. Rep. Fish. Aquat. Sci. 1285: 71 p.

On a étudié la distribution annuelle des débarquements de saumon rouge, de 1967 à 1981, en fonction de la taille de la flottille de pêche commerciale. Chaque année, 90 % des débarquements ont été effectués, en moyenne, par 1,855 bateaux de pêche aux filets maillants. De ces bateaux, 56 % ont débarqué moins de 1,000 saumons rouges annuellement et les premiers 50 % ont effectué 81 % des prises totales annuelles. Une moyenne de 290 senneurs, dont 41 % ont débarqué moins de 2,000 poissons annuellement, ont capturé 90 % des prises. Les premiers 50 % de ces senneurs ont pêché 84 % des prises totales annuelles. En moyenne, 777 bateaux de pêche à la traîne ont effectué 90 % des débarquements annuels de saumon rouge. Environ 88 % de tous les bateaux de pêche à la traîne ont capturé moins de 400 poissons annuellement et les premiers 50 % se sont appropriés 94 % des prises totales annuelles.

Mots-clés: Colombie-Britannique, prise, exploitation, filet maillant, senne, saumon rouge, ligne traînante

INTRODUCTION

The British Columbia commercial fishing fleet for salmon is currently too large, given the amount of salmon to be harvested and the efficiency of the fleet to do so. A commission on Pacific fisheries policy suggested that the salmon fleet be reduced to half of its present capacity over a 10-year period (Pearse 1982). This reduction in fleet capacity was suggested to be accomplished by a buy-back program. In an evaluation of a buy-back program, a committee was established to recommend in part the number of vessels that should be present in the fishery after the buy-back program is completed. The recommendation for the salmon fleet was for 400 seiners, 1467 trollers, and 2208 gillnet plus gillnet/troll combination vessels (Cruickshank et al. 1982). This would represent a 25% decrease in the number of seiners (from 532 to 400), 12% for trollers (from 1667 to 1467), and 12% from gillnet plus gillnet/troll combination vessels (from 2508 to 2208). However, it is uncertain what the degree of redistribution of the landings would be if the suggested number of vessels were removed from the fleet.

Incomes are distributed non-uniformly among fishermen (Sinclair 1978). Landings of salmon may also be distributed non-uniformly among different vessels participating in the salmon fishery. The present report details the distribution of landings of sockeye salmon (Oncorhynchus nerka) in relation to the size of the commercial fishing fleet and indicates the degree of redistribution of the landings that may be expected when decisions on fleet size are made.

An analysis was conducted in order to determine the distribution of catch in relation to the number of commercial fishing vessels for each species of Pacific salmon and for all species combined on a weight basis. This analysis was conducted for each of the major gear components in the British Columbia salmon fishery (gillnet, seine, and troll). When the distribution of catch of Pacific salmon in relation to the size of the commercial fleet is known, decisions can be made on the level to which the fleet could be reduced. The present report deals with the distribution of landings of sockeye salmon during 1967-1981 in relation to the number of commercial fishing vessels in British Columbia and it is the third in a series of reports on the distribution of landings of Pacific salmon.

MATERIALS AND METHODS

The information upon which the distribution of landings in relation to the size of the commercial fishing fleet is determined is derived from sales-slips. Wong (1983) has described the procedure used in recording and editing the information contained on the sales-slip. Summarized briefly, sales-slips are generated when the catch is delivered for processing or sold, and information on the commercial fishing vessel (CFV) license number, gear, area, period, and weight or numbers of species caught is recorded.

Sales-slips lacking numbers of salmon landed but containing the weight landed are adjusted for numbers by dividing the weight by the mean weight of the particular species, area, and gear that are applicable.

The analysis in the present study depended upon compiling the annual landings by species for each commercial fishing vessel in the three major gear classifications: purse seiner, gillnetter, and troller. This should be confidential information, so that, as outlined by Wong (1983), original commercial fishing vessel license numbers are converted to different codes by a standard method each year, so that it is not possible to relate catches to a specific vessel without authorization. The analysis for this report used solely the transformed license numbers.

The analysis of the sales-slips revealed that in some instances, there would be only 1 sales-slip for a particular license number in one of the three gear classes in a year. These were assumed to be errors in recording the license number, and were deleted in the subsequent description of the distribution of the catch. The distribution of catch was summarized in two ways, the first being by the number of vessels in a particular gear class, and the second by the percentage of vessels in a particular gear class. The number of vessels that landed salmon in a particular gear class was not constant during 1967-1981, so that both methods were used to describe the catch distribution.

Landings from combination vessels (gillnet and troll gear) were assigned to the gear used to catch the salmon sold at the time that the sales-slip was generated. Landings from a combination vessel would thus appear in both the troll and gillnet gear classes as appropriate.

The salmon sales-slip data tapes upon which the present analysis is based were derived from Wong (1983). The number of purse seiners recorded landing sockeye salmon in 1980 and 1981 was greater than the number of licensed vessels. It was assumed that errors were made in recording the gear of some commercial fishing vessel license numbers so that the maximum number of purse seiners in 1980 and 1981 was set at the number of licenses (532). For the analysis in this report, landings of sockeye salmon by purse seine vessels were arranged in descending order and landings from the 533rd vessel onwards were deleted. This removed those vessels with the smallest annual landings of sockeye salmon.

The top 200 vessels in terms of landings for a particular species were recorded annually for trollers and gillnetters during 1967-1981. The top 100 seiners were recorded annually during 1969-1981. When the top vessels were identified in a particular year, it was possible to examine how many were also in the top category in previous and subsequent years. For example, once the top 200 gillnetters for sockeye salmon had been identified in 1975, it was possible to examine how many of these same vessels were in the top 200 gillnetters for sockeye salmon in 1973 or 1981. This analysis was conducted in order to determine whether or not some vessels were successful on a continuing basis.

The analysis of distribution of landings in relation to the number of vessels in each fleet component first proceeded by determining annual landings for each species for each vessel in the three gear categories.

Vessels were then sorted in descending order based upon the size of the landings for each species. Once the total catch and the total number of vessels that participated in the fishery for each species were determined, it was then possible to calculate the proportion of the catch that was taken by different numbers of vessels and also different proportions of the fleet. The number and percentage of vessels that landed different numbers of salmon were also calculated.

RESULTS

GILLNET COMPONENT

The landings of sockeye salmon by gillnetters have ranged from 1.3 to 5.2 million pieces annually during 1967 to 1981 (Table 1). Landings in excess of 4 million pieces were made in 1967, 1968, and 1973. The gillnet share of the total landings of sockeye salmon has declined relative to the other gears when landings are considered on a coast-wide basis. Prior to 1970 gillnetters accounted for at least 60% of the coast-wide landings, but their share of the total landings declined to about 40% in 1980 and 1981.

The distribution of total landings of sockeye salmon in relation to the number of vessels participating in the gillnet fishery was examined on an annual basis during 1967-1981 (Appendix A, Tables A1-A15). This 15-year distribution of the landings in relation to the number of vessels in the fishery is summarized in Figure 1. About 1855 vessels accounted for an average of 90% of the total landings in any year. When landings exceeded 4 million pieces, 90% of the landings were accounted for by between 1800 and 2150 vessels (Table 2). The largest gillnet landings of sockeye salmon were recorded in 1973, and in that year 1811 vessels accounted for 90% of the total landings. The top 1465 vessels accounted for an average of 80% of the total landings in any year (Table 2). The increase in landings in moving from 80 to 90% of the total landings was accompanied by an increase in the number of vessels by 27%. In examining the number of vessels that account for 100% of the landings as compared with 90%, the number increased 61% from 1855 to 2995 vessels.

The frequency of total landings per vessel was also investigated on an annual basis. An average of 56% of the vessels participating in the gillnet fishery for sockeye salmon landed less than 1000 sockeye salmon annually during 1967-1981 (Table 3). About 4% of the vessels landed more than 3000 sockeye salmon annually. The poorest 33% of the vessels participating in the gillnet fishery land less than 500 sockeye salmon each in most years. The top 50% of the vessels participating in the gillnet fishery during 1967-1981 accounted for, on average, 81% of the total annual landings (Table 4). This 81% share of the total gillnet landings of sockeye salmon was accounted for by 1480 vessels.

The repeatability of success in landing sockeye salmon was examined by identifying the top 200 gillnetters in each year during 1967-1981 and tallying how many of these 200 were in the top 200 in all other years. The results are illustrated in Table 5. With an average of 2995 vessels in the fishery and under the assumption of a random distribution of the top 200 vessels in all years except the one in which they were the top 200 vessels, one would expect an average of (200/2995) x 200 = 13 vessels to appear by chance. If 20 or more appear, there is a significant statistical association ($x^2 = 3.84$, $P < 0.05$), which indicates that vessels successful in one year were also successful in previous and successive years. For example, if one examines the top 200 vessels in 1974, there were a significant number of these vessels that were also in the top 200 vessels during 1967-1981 (Table 5). This analysis indicates that successful sockeye salmon gillnet vessels tend to be successful on a continuing basis.

SEINE COMPONENT

The landings of sockeye salmon by purse seiners have ranged from 0.5 million pieces in 1975 to 4.6 million pieces in 1981 (Table 1). The proportion of the total landings accounted for by purse seiners has increased from about 30% in 1967 to about 60% in 1980 and 1981.

The distribution of total landings of sockeye salmon in relation to the number of purse seiners was examined on an annual basis during 1967-1981 (Appendix B, Tables B1-B15). The distribution of the landings in relation to the number of purse seiners participating in the fishery is summarized in Figure 2. On an average basis between 1967 and 1981, about 290 purse seiners accounted for 90% of the total landings in any year. However, in 1975, when 0.5 million pieces were landed, 265 vessels accounted for 90% of the total landings, and in 1981, when 4.6 million pieces of sockeye salmon were landed by purse seiners, 376 vessels accounted for 90% of the total (Table 6). An average of 222 vessels accounted for 80% of the total landings in any year. In moving from 80 to 90% of the total landings of sockeye salmon, the number of vessels increased from 222 to 288. This increase in catch was accounted for by a 30% increase in the number of vessels. In examining the number of vessels that account for 100% of the landings, the number was, on average, 489, an increase of 70% over the number of vessels accounting for 90% of the landings.

The frequency of total landings per vessel was also investigated on an annual basis. About 41% of the purse seiners participating in the sockeye salmon fishery landed less than 2,000 pieces annually (Table 7). An average of about 9% of the vessels landed in excess of 10,000 pieces annually. The top 50% of the vessels participating in the fishery during 1967-1981 accounted for, on average, 84% of the total annual landings (Table 4). This 80% of the total purse seine landings of sockeye salmon was previously noted to be accounted for by the top 222 purse seiners.

The annual repeatability of success in landing sockeye salmon in the purse seine fishery was examined by identifying the top 100 seiners in each year during 1969-1981 and tallying how many of these 100 were in the top 100

in all other years (Table 8). Using an average of 489 vessels in the fishery, one would expect, under the assumption of a random distribution of the top 100 vessels in all years except the one in which they were the top 100 vessels, that an average of (100/489) x 100 = 20 vessels to appear by chance. If 29 or more vessels appear, this indicates that vessels successful in one year (the diagonal of 100s in Table 9) were also successful in the year for which 29 or more vessels are counted ($x^2 = 3.84$, $P < 0.05$). For example, the top 100 seiners for sockeye salmon in 1976 were also more successful for sockeye salmon during 1971-1979 than one would expect by chance (Table 9). There is some evidence to indicate that successful sockeye salmon purse seine vessels tend to be successful for a range of years.

TROLL COMPONENT

Landings of troll-caught sockeye salmon have ranged between 42 thousand pieces (1972) and 1.1 million pieces (1978) (Table 1). Landings in excess of 800 thousand pieces were recorded in 1974 and 1978, coincident with strong returns of Adams River sockeye salmon.

The distribution of total landings of sockeye salmon in relation to the number of vessels that used troll gear to land sockeye salmon was examined on an annual basis during 1967-1981 (Appendix C, Tables C1-C15). The distribution of landings of sockeye salmon in relation to the number of vessels using troll gear that participated in the fishery is summarized in Fig. 3. On an average basis between 1967 and 1981, about 777 trollers accounted for 90% of the landings in any year (Table 9). Trollers had the greatest landing of sockeye salmon in any year during 1967-1981 in 1978, and in that year, 951 vessels accounted for 90% of the total landings. The best 816 trollers accounted for 90% of the landings in 1974. On an average basis between 1967 and 1981, the top 536 vessels accounted for 80% of the landings in any year. In increasing from 80 to 90% of the total troll-caught landings of sockeye salmon, the average number of vessels that accounted for the catch increased from 536 to 777, an increase of 45%. An average of 1968 vessels accounted for 100% of troll-caught sockeye salmon, an increase of 153% over the number of vessels accounting for 90% of the landings.

The frequency of total landings per vessel was also investigated on an annual basis during 1967-1981. An average of 76 vessels landed more than 1000 sockeye salmon annually (Table 10). Of the vessels that used troll gear to land sockeye salmon, about 80% of these vessels landed less than 200 troll-caught sockeye salmon annually. The top 50% of the vessels that landed troll-caught sockeye salmon during 1967-1981 accounted for 94% of the total annual landings (Table 4).

The annual repeatability of success in landing sockeye salmon in the troll fishery was examined by identifying the top 200 vessels in each year during 1967-1981, and tallying how many of these 200 were in the top 200 in all other years (Table 11). Using an average of 1968 vessels in the fishery, one would expect, under the assumption of a random distribution of the top 200 vessels in all years except the one in which they were the top 200 vessels,

that an average of (200 x 200/1968) = 20 vessels to appear by chance. If 29 or more vessels appear, this indicates that the vessels successful in one year (the diagonal of 200s in Table 11) were also successful in the year in which 29 or more vessels were counted ($x^2 = 3.84$, $P < 0.05$). For example, the top 200 trollers in 1977 were also more successful for sockeye salmon during 1973 to 1981 than one would expect by chance alone (Table 11). This analysis suggests that successful troll vessels for sockeye salmon tend to be successful for a number of years.

DISCUSSION

The number of vessels accounting for 90% of the harvest of British Columbia sockeye salmon under a similar management policy as was instituted during 1967-1981 was found to be about 1855 gillnet vessels, 290 purse seine vessels, and 780 trollers. Troll landings in excess of 800 thousand pieces were accounted for by between 815 and 950 trollers. Reducing the size of the commercial fleet to the previously noted levels would not significantly reduce the overall landings of sockeye salmon nor the exploitation rates on the species. With less competition among vessels of each gear class under a reduced fleet size, the exploitation rate of an average vessel could increase to the extent that overall exploitation rates on sockeye salmon stocks could increase. Exploitation rates must necessarily continue to be regulated by restrictions on fishing time and locations.

The number of vessels of each gear class that the present analysis indicates would be sufficient to harvest British Columbia sockeye salmon is less than the recommendations of a British Columbia fleet rationalization committee of 2208 gillnetters, 400 seiners, and 1467 trollers (Cruickshank et al. 1982). The present analysis suggests that the number of seiners could be reduced by 45% (from 532 to 290), gillnetters and combination gillnet/troll vessels by 26% (from 2508 to 1855), and trollers by 53% (from 1667 to 780) and the landings of sockeye salmon would not be significantly reduced. It is assumed that the least effective vessels would be removed from the fishery. The present analysis deals only with sockeye salmon landings, but the results for the other species are similar. For example, an average of 1320 gillnetters and 305 seiners accounted for 90% of the landings for each gear type of pink salmon in British Columbia during 1967-1981. An average of 1290 gillnetters and 290 seiners accounted for 90% of the landings for each gear type of chum salmon (Beacham unpublished data).

Reduction of fleet size to the levels suggested by the fleet rationalization committee (Cruickshank et al. 1982) were projected to result in rapid rises in income to the vessels remaining in the commercial fleet. The present analysis for sockeye salmon suggests that if the least efficient vessels are removed from the fleet, mean landings of sockeye salmon per vessel will not increase and thus mean gross income per vessel remaining in the fleet will not increase, as long as total catches do not increase and prices remain stable.

The present report outlines the number of vessels necessary to harvest British Columbia sockeye salmon in the commercial fleet if current management practices are continued and gear distributions of catch are maintained. It does not consider the social implications of reduction of fleet size and these should be considered in the establishment of targets for a reduced size of the commercial salmon fleet in British Columbia.

ACKNOWLEDGMENTS

Mr. Fred Wong made available the data upon which the distribution of landings of salmon in relation to fleet size was determined.
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Table 1. Commercial landings (thousands of pieces) of sockeye salmon in British Columbia, 1967-1981.

Year	Gillnet	Seine	Troll	Total
1967	4447	1952	2912	6691
1968	4915	1239	1907	6345
1969	3340	737	1893	4267
1970	2494	1193	3903	4077
1971	3726	1944	6351	6306
1972	2704	816	421	3562
1973	5230	2179	1654	7575
1974	3628	2692	9059	7225
1975	1639	522	108	2271
1976	2912	1787	1141	4813
1977	3783	2433	128	6346
1978	2465	3687	1068	7221
1979	2916	2350	424	5691
1980	1341	1865	53	3260
1981	3679	4636	127	844

Table 2. Number of gillnetters accounting for varying percentages of the total gillnet landings of sockeye salmon, 1967-1981.

Percent of total landings	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1967-1981
10	117	111	101	101	110	87	99	85	29	68	95	83	77	51	81	86
20	269	258	247	231	252	212	228	203	108	171	218	193	176	125	183	205
30	446	429	426	382	418	361	378	345	213	308	364	327	291	222	301	347
40	644	623	637	553	606	530	545	508	346	477	532	481	422	341	434	512
50	864	844	883	749	817	724	730	690	513	673	724	656	570	485	585	700
60	1110	1095	1166	974	1054	948	937	897	712	895	943	855	737	656	757	916
70	1386	1380	1492	1243	1325	1209	1172	1135	956	1151	1194	1087	930	865	955	1165
80	1710	1719	1870	1579	1649	1523	1452	1424	1262	1459	1497	1362	1161	1121	1191	1855
90	2126	2150	2336	2047	2075	1939	1811	1803	1682	1841	1888	1713	1456	1470	1492	1855
100	3563	3510	3520	3598	3576	3279	2868	2947	2804	2724	2733	2694	2241	2580	2383	2995

Table 3. Frequencies (and percentage) of vessels landing sockeye salmon in British Columbia by gillnets, 1967-1981.

Catch interval (pieces)	Year 1967	1968	1969	1970	1971	1972	1973	1974
0-500	1062 (29.8)	960 (27.4)	940 (26.7)	1773 (49.3)	1206 (33.7)	1303 (39.7)	572 (19.9)	872 (29.6)
501 -1000	554 (15.5)	626 (17.8)	1197 (34.0)	878 (24.4)	706 (19.7)	875 (26.7)	403 (14.1)	521 (17.7)
1001-1500	642 (18.0)	689 (19.6)	790 (22.4)	578 (16.1)	662 (18.5)	605 (18.5)	346 (12.1)	542 (18.4)
1501-2000	616 (17.3)	551 (15.7)	329 (9.3)	266 (7.4)	530 (14.8)	313 (9.5)	400 (13.9)	444 (15.1)
2001-2500	388 (10.9)	352 (10.0)	145 (4.1)	78 (2.2)	262 (7.3)	108 (3.3)	400 (13.9)	290 (9.8)
2501-3000	171 (4.8)	174 (5.0)	55 (1.6)	18 (0.5)	141 (3.9)	42 (1.3)	309 (10.8)	132 (4.5)
3001-3500	78 (2.2)	88 (2.5)	40 (1.1)	5 (0.1)	45 (1.3)	18 (0.5)	198 (6.9)	78 (2.6)
3501-4000	26 (0.7)	41 (1.2)	9 (0.3)	0 (0.0)	11 (0.3)	7 (0.2)	116 (4.0)	32 (1.1)
4000+	26 (0.7)	29 (0.8)	15 (0.4)	2 (0.1)	13 (0.4)	8 (0.2)	124 (4.3)	36 (1.2)
Total	3563	3510	3520	3598	3576	3279	2868	2947

Catch interval (pieces)	Year 1975	1976	1977	1978	1979	1980	1981	1967-1981
0-500	1642 (58.6)	692 (25.4)	458 (16.8)	781 (30.1)	513 (22.9)	1631 (63.2)	545 (22.9)	997 (33.3)
501 -1000	773 (27.6)	890 (32.7)	645 (23.6)	780 (30.1)	451 (20.1)	646 (25.0)	351 (14.7)	686 (22.9)
1001-1500	218 (7.8)	655 (24.0)	572 (20.9)	572 (22.1)	457 (20.4)	183 (7.1)	408 (17.1)	528 (17.6)
1501-2000	104 (3.7)	248 (9.1)	473 (17.3)	280 (10.8)	360 (16.1)	83 (3.2)	350 (14.7)	356 (11.9)
2001-2500	38 (1.4)	102 (3.7)	273 (10.0)	104 (4.0)	228 (10.2)	21 (0.8)	280 (11.7)	205 (6.8)
2501-3000	14 (0.5)	52 (1.9)	148 (5.4)	49 (1.9)	130 (5.8)	8 (0.3)	200 (8.4)	110 (3.7)
3001-3500	9 (0.3)	39 (1.4)	90 (3.3)	17 (0.7)	58 (2.6)	6 (0.2)	118 (5.0)	59 (2.0)
3501-4000	2 (0.1)	19 (0.7)	44 (1.6)	10 (0.4)	23 (1.0)	2 (0.1)	71 (3.0)	28 (0.9)
4000+	3 (0.1)	27 (1.0)	30 (1.1)	1 (0.0)	21 (0.0)	0 (0.0)	60 (2.5)	26 (0.9)
Total	2804	2724	2733	2594	2241	2580	2383	2995

Table 4. Percentage of total landings of sockeye salmon that the top 50% of the vessels participating in the fishery account for in each gear type.

Year	Gillnet	Seine	Troll
1967	82	84	95
1968	81	92	96
1969	78	85	96
1970	85	92	95
1971	83	92	98
1972	83	90	94
1973	80	87	95
1974	82	78	94
1975	84	87	97
1976	77	86	94
1977	76	72	91
1978	78	79	94
1979	78	77	94
1980	85	79	92
1981	80	74	92
Mean	81	84	94

Table 5. A measure of the repeatability of success of landing sockeye salmon by gillnetters. The top 200 gillnetters in terms of sockeye salmon landings were identified each year (diagonal in table). The number of times that those 200 vessels were in the top 200 in previous and subsequent years is recorded by column. For example, of the top 200 gillnetters in 1972, and 48 in the top 200 in 1981. Twenty or more vessels is indicative of a significant statistical association.

Year	Year														
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1967	200	39	34	32	26	30	30	28	15	10	13	7	8	7	9
1968	39	200	56	39	47	33	32	28	24	32	14	23	8	14	6
1969	34	56	200	77	68	64	55	49	43	45	29	37	15	24	24
1970	32	39	77	200	62	65	61	54	36	43	39	30	23	22	24
1971	26	47	68	62	200	66	63	73	41	54	33	44	20	29	24
1972	30	33	64	65	66	200	76	67	38	55	44	44	27	27	26
1973	30	32	55	61	63	76	200	80	48	47	55	45	32	27	30
1974	28	28	49	54	73	67	80	200	56	69	63	56	45	38	39
1975	15	24	43	36	41	38	48	56	200	76	50	55	34	40	29
1976	10	32	45	43	54	55	47	69	76	200	67	55	32	62	34
1977	13	14	29	39	33	44	55	63	50	67	200	51	68	54	48
1978	7	23	37	30	44	44	45	56	55	55	51	200	40	55	53
1979	8	8	15	23	20	27	32	45	34	32	68	40	200	59	69
1980	7	14	24	22	29	27	27	38	40	62	54	55	59	200	70
1981	9	6	24	24	24	26	30	39	29	34	48	53	69	70	200

Table 6. Number of purse seiners accounting for varying percentages of the total purse seine landings of sockeye salmon, 1967-1981.

Percent of total landings	Year															
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1967-1981
10	18	10	9	13	9	8	12	17	7	11	20	15	18	16	21	14
20	39	23	21	29	20	19	26	39	18	26	46	35	40	38	47	31
30	63	37	36	47	32	31	43	66	31	44	76	59	65	65	77	52
40	90	55	52	69	46	46	63	95	49	67	109	88	94	95	112	75
50	119	75	74	92	65	64	85	128	72	93	147	121	128	130	150	103
60	152	99	102	118	89	88	110	164	101	123	189	159	168	171	193	135
70	190	128	138	149	123	118	140	203	138	161	238	203	216	217	243	174
80	234	162	184	188	167	163	182	250	191	207	294	254	276	273	302	222
90	290	212	249	247	229	233	242	312	265	273	363	319	355	348	376	288
100	514	455	425	527	503	474	437	486	475	479	489	496	514	532	532	489

Table 7. Frequencies (and percentage) of vessels landing sockeye salmon in British Columbia by purse seines, 1967-1981.

Catch interval (pieces)	Year 1967	1968	1969	1970	1971	1972	1973	1974
0-2000	180 (35.0)	251 (55.2)	301 (70.8)	304 (57.7)	252 (50.1)	344 (72.6)	156 (35.7)	104 (21.4)
2001-4000	101 (19.6)	84 (18.5)	73 (17.2)	97 (18.4)	90 (17.9)	69 (14.6)	84 (19.2)	88 (18.1)
4001-6000	104 (20.2)	60 (13.2)	34 (8.0)	79 (15.0)	59 (11.7)	32 (6.8)	58 (13.3)	77 (15.8)
6001-8000	73 (14.2)	27 (5.9)	13 (3.1)	33 (6.3)	26 (5.2)	16 (3.4)	26 (5.9)	94 (19.3)
8001-10,000	42 (8.2)	20 (4.4)	2 (0.5)	11 (2.1)	15 (3.0)	9 (1.9)	46 (10.5)	69 (14.2)
10,001-12,000	11 (2.1)	8 (1.8)	2 (0.5)	3 (0.6)	15 (3.0)	4 (0.8)	30 (6.9)	29 (6.0)
12,001-14,000	1 (0.2)	4 (0.9)	0 (0.0)	0 (0.0)	11 (2.2)	0 (0.0)	13 (3.0)	9 (1.9)
14,001-16,000	2 (0.4)	1 (0.2)	0 (0.0)	0 (0.0)	11 (2.2)	0 (0.0)	9 (2.1)	9 (1.9)
16,001+	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	24 (4.8)	0 (0.0)	15 (3.4)	7 (1.4)
Total	514	455	425	527	503	474	437	486

Catch interval (pieces)	Year 1975	1976	1977	1978	1979	1980	1981	1967-1981
0-2000	399 (84.0)	208 (43.4)	56 (11.5)	94 (19.0)	118 (23.0)	184 (34.6)	47 (8.8)	200 (40.9)
2001-4000	55 (11.6)	96 (20.0)	141 (28.8)	58 (11.7)	154 (30.0)	153 (28.8)	66 (12.4)	94 (19.2)
4001-6000	16 (3.4)	74 (15.4)	141 (28.8)	66 (13.3)	100 (19.5)	112 (21.1)	67 (12.6)	72 (14.7)
6001-8000	2 (0.4)	46 (9.6)	84 (17.2)	82 (16.5)	59 (11.5)	53 (10.0)	87 (16.4)	48 (9.8)
8001-10,000	2 (0.4)	29 (6.1)	47 (9.6)	69 (13.9)	48 (9.3)	17 (3.2)	71 (13.3)	33 (6.7)
10,001-12,000	1 (0.2)	7 (1.5)	10 (2.0)	39 (7.9)	21 (4.1)	9 (1.7)	61 (11.5)	17 (3.5)
12,001-14,000	0 (0.0)	11 (2.3)	6 (1.2)	27 (5.4)	8 (1.6)	2 (0.4)	49 (9.2)	9 (1.8)
14,001-16,000	0 (0.0)	1 (0.2)	3 (0.6)	21 (4.2)	3 (0.6)	1 (0.2)	34 (6.4)	6 (1.2)
16,000+	0 (0.0)	7 (1.5)	1 (0.2)	40 (8.1)	3 (0.6)	1 (0.2)	50 (9.4)	10 (2.0)
Total	475	479	489	496	514	532	532	489

Table 8. A measure of the repeatability of successes of landing sockeye salmon by purse seiners. The top 100 seiners in terms of sockeye salmon landings were identified each year (diagonal in table). The number of times that those 100 vessels were in the top 100 in previous and subsequent years is recorded by column. For example, of the top 100 seiners in 1976, 39 of those 100 were in the top 100 in 1971 and 36 were in the top 100 in 1979. Twenty-nine or more vessels is indicative of a significant statistical association.

Year	Year												
	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1969	100	49	54	55	46	33	18	34	27	16	22	15	13
1970	49	100	43	43	29	28	15	22	23	14	20	13	12
1971	54	43	100	51	63	39	18	39	24	16	25	16	12
1972	55	43	51	100	42	33	19	32	30	16	26	21	15
1973	46	29	63	42	100	43	22	43	26	16	23	13	9
1974	33	28	39	33	43	100	18	42	30	26	22	20	16
1975	18	15	18	19	22	18	100	29	25	23	11	15	13
1976	34	22	39	32	43	42	29	100	45	32	36	26	24
1977	27	23	24	30	26	30	25	45	100	42	36	29	30
1978	16	14	16	16	16	26	23	32	42	100	34	37	39
1979	22	20	25	26	23	22	11	36	36	34	100	39	41
1980	15	13	16	21	13	20	15	26	29	37	39	100	46
1981	13	12	12	15	9	16	13	24	30	39	41	46	100

Table 9. Number of trollers accounting for varying percentages of the total troll-caught landings of sockeye salmon, 1967-1981.

Percent of total landings	Year															
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1967-1981
10	15	10	19	27	28	7	13	31	8	7	23	39	33	11	24	20
20	36	22	49	64	68	20	33	76	18	24	62	94	78	33	61	49
30	64	34	89	110	117	41	60	129	33	48	117	160	133	66	113	88
40	108	50	138	170	175	72	97	190	55	82	189	237	201	115	183	131
50	172	65	200	245	242	115	146	263	86	131	281	327	280	183	269	200
60	256	87	276	337	321	178	212	351	127	205	398	431	377	281	375	281
70	371	124	378	455	416	274	306	462	182	308	545	554	500	417	514	387
80	531	194	515	614	540	427	439	607	266	457	736	713	666	625	710	536
90	788	333	735	864	722	692	662	816	431	696	1,029	951	954	975	1,008	777
100	2,214	1,128	2,017	2,264	2,236	1,751	1,780	1,916	1,449	1,745	2,103	2,181	2,382	2,155	2,192	1,968

Table 10. Frequencies (and percentage) of vessels landing sockeye salmon in British Columbia by troll gear, 1967-1981.

Catch interval (pieces)	Year 1967	1968	1969	1970	1971	1972	1973	1974
0- 200	1815 (82.0)	894 (79.3)	1718 (85.2)	1643 (72.6)	1439 (64.4)	1722 (98.3)	1558 (87.5)	919 (48.0)
201- 400	238 (10.7)	104 (9.2)	192 (9.5)	307 (13.6)	214 (9.6)	21 (1.2)	130 (7.3)	258 (13.5)
401- 600	71 (3.2)	26 (2.3)	74 (3.7)	159 (7.0)	168 (7.5)	6 (0.3)	43 (2.4)	189 (9.9)
601- 800	23 (1.0)	21 (1.9)	19 (0.9)	63 (2.8)	133 (5.9)	0 (0.0)	29 (1.6)	135 (7.0)
801-1000	20 (0.9)	14 (1.2)	7 (0.3)	39 (1.7)	101 (4.5)	1 (0.1)	9 (0.5)	96 (5.0)
1000-1200	11 (0.5)	0 (0.0)	2 (0.1)	24 (1.1)	65 (2.9)	1 (0.1	5 (0.3)	75 (3.9)
1201-1400	12 (0.5)	1 (0.1)	3 (0.2)	15 (0.7)	50 (2.2)	0 (0.0)	3 (0.2)	71 (3.7)
1401-1600	8 (0.4)	37 (3.3)	0 (0.0)	10 (0.4)	22 (1.0)	0 (0.0)	1 (0.1)	53 (2.8)
1601-1800	8 (0.4)	0 (0.0)	1 (0.0)	2 (0.1)	20 (0.9)	0 (0.0)	1 (0.1)	34 (1.8)
1800+	8 (0.4)	31 (2.7)	1 (0.0)	2 (0.1)	24 (1.1)	0 (0.0)	1 (0.1)	86 (4.5)
Total	2214	1128	2017	2264	2236	1751	1780	1916

Catch interval (pieces)	Year 1975	1976	1977	1978	1979	1980	1981	1967-1981
0- 200	1299 (89.6)	1619 (92.8)	1984 (94.3)	1025 (47.0)	1694 (71.1)	2122 (98.5)	2077 (94.8)	1570 (79.8)
201- 400	97 (6.7)	76 (4.4)	95 (4.5)	268 (12.3)	320 (13.4)	24 (1.1)	89 (4.1)	162 (8.2)
401- 600	19 (1.3)	32 (1.8)	21 (1.0)	210 (9.6)	181 (7.6)	7 (0.3)	20 (0.9)	82 (4.2)
601- 800	14 (1.0)	11 (0.6)	1 (0.1)	131 (6.0)	96 (4.0)	2 (0.1)	4 (0.2)	45 (2.3)
801-1000	7 (0.5)	3 (0.2)	0 (0.0)	151 (6.9)	51 (2.1)	0 (0.0)	2 (0.1)	33 (1.7)
1001-1200	5 (0.3)	1 (0.1)	1 (0.1)	120 (5.5)	23 (1.0)	0 (0.0)	0 (0.0)	22 (1.1)
1201-1400	3 (0.2)	1 (0.1)	1 (0.1)	83 (3.8)	10 (0.4)	0 (0.0)	0 (0.0)	17 (0.9)
1401-1600	4 (0.3)	0 (0.0)	0 (0.0)	69 (3.2)	6 (0.3)	0 (0.0)	0 (0.0)	14 (0.7)
1601-1800	0 (0.0)	1 (0.1)	0 (0.0)	39 (1.8)	0 (0.0)	0 (0.0)	0 (0.0)	7 (0.7)
1800+	1 (0.1)	1 (0.1)	0 (0.0)	85 (3.9)	1 (0.1)	0 (0.0)	0 (0.0)	16 (0.8)
Total	1449	1745	2103	2182	2382	2155	2192	1968

Table 11. A measure of the repeatability of success of landing sockeye salmon by trollers. The top 200 trollers in terms of sockeye salmon landings were identified each year (diagonal in table). The number of times that those 200 vessels were in the top 200 in previous and subsequent years is recorded by column. For example, of the top 200 trollers in 1977, 37 of those 200 were in the top 200 in 1971 and 30 in the top 200 in 1981. Twenty-nine or more vessels is indicative of a significant statistical association.

	Year														
Year	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1967	200	22	35	66	57	26	42	33	26	23	16	12	17	5	13
1968	22	200	26	21	16	14	17	18	10	11	11	8	11	5	9
1969	35	26	200	57	62	40	34	25	16	24	12	15	19	12	9
1970	66	21	57	200	82	36	62	49	32	31	21	18	18	13	18
1971	57	16	62	82	200	46	59	47	29	28	37	24	31	13	12
1972	26	14	40	36	46	200	39	26	35	37	23	18	19	13	11
1973	42	17	34	62	59	39	200	66	52	54	38	23	26	16	22
1974	33	18	25	49	47	26	66	200	54	36	37	50	41	15	24
1975	26	10	16	32	29	35	52	54	200	49	41	28	28	14	24
1976	23	11	24	31	28	37	54	36	49	200	58	20	32	24	23
1977	16	11	12	21	37	23	38	37	41	58	200	40	31	31	30
1978	12	8	15	18	24	18	23	50	28	20	40	200	51	26	22
1979	17	11	19	18	31	19	26	41	28	32	31	51	200	17	21
1980	5	5	12	13	13	13	16	15	14	24	31	26	17	200	47
1981	13	9	9	18	12	11	22	24	24	23	30	22	21	47	200

FIGURES

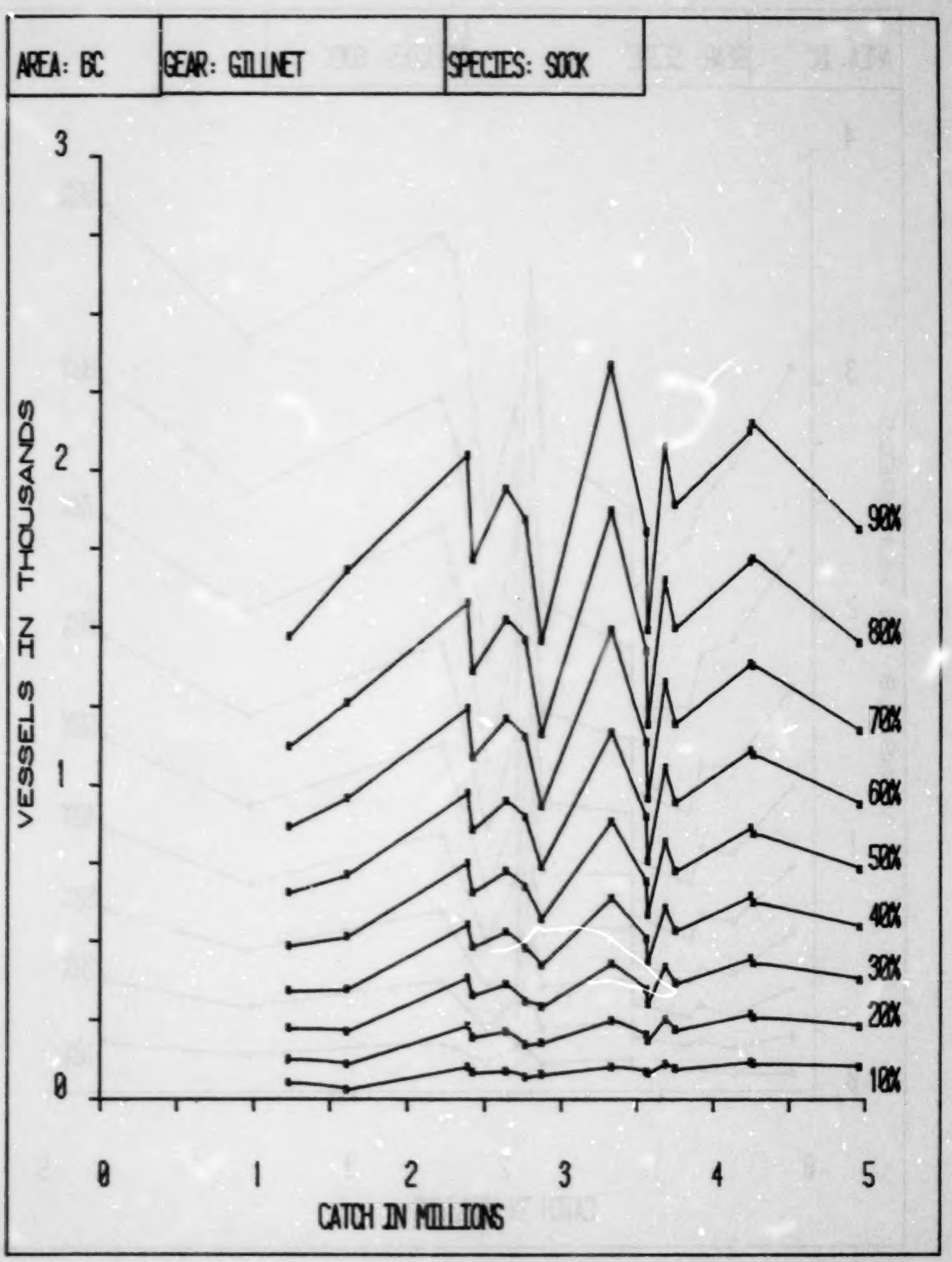

Fig. 1. Contour plots for the number of gillnetters that harvested a fixed percentage of the total annual catch of sockeye salmon by gillnetters versus the size of the annual catch during 1967-1981.

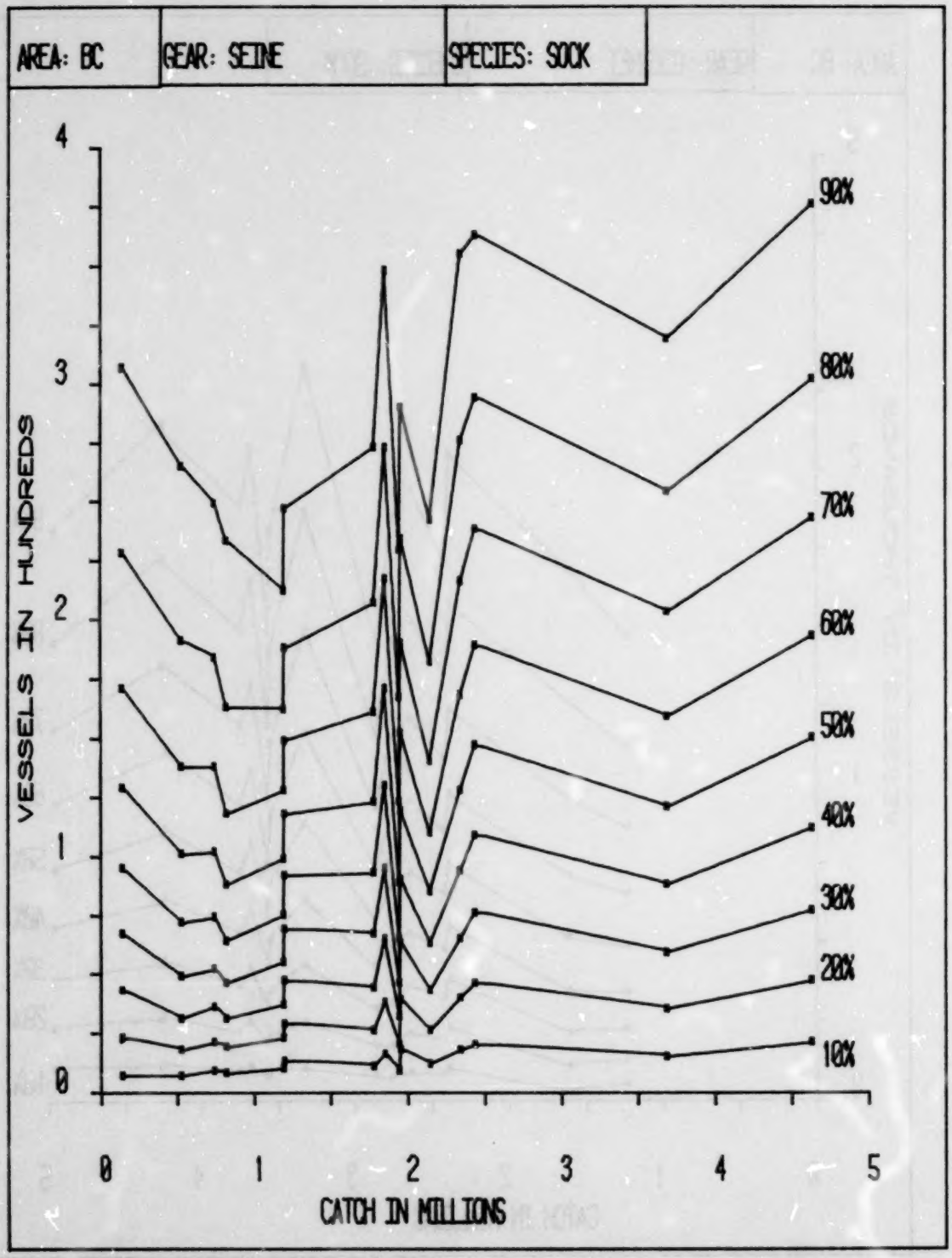

Fig. 2. Contour plots for the number of seiners that harvested a fixed percentage of the total annual catch of sockeye salmon by seiners versus the size of the annual catch during 1967-1981.

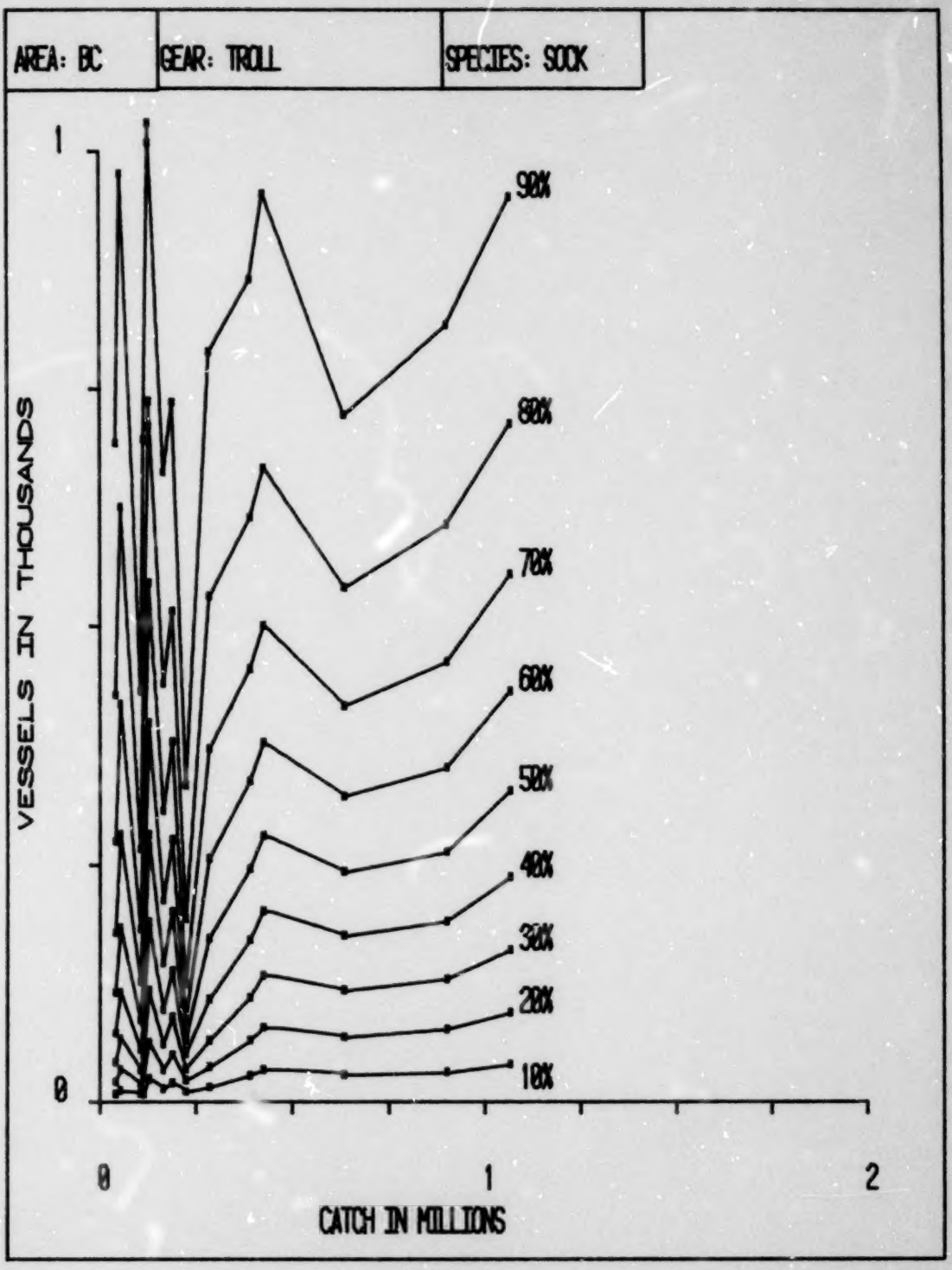

Fig. 3. Contour plots for the number of trollers that harvested a fixed percentage of the total annual catch of sockeye salmon by trollers versus the size of the annual catch during 1967-1981.

APPENDIX A

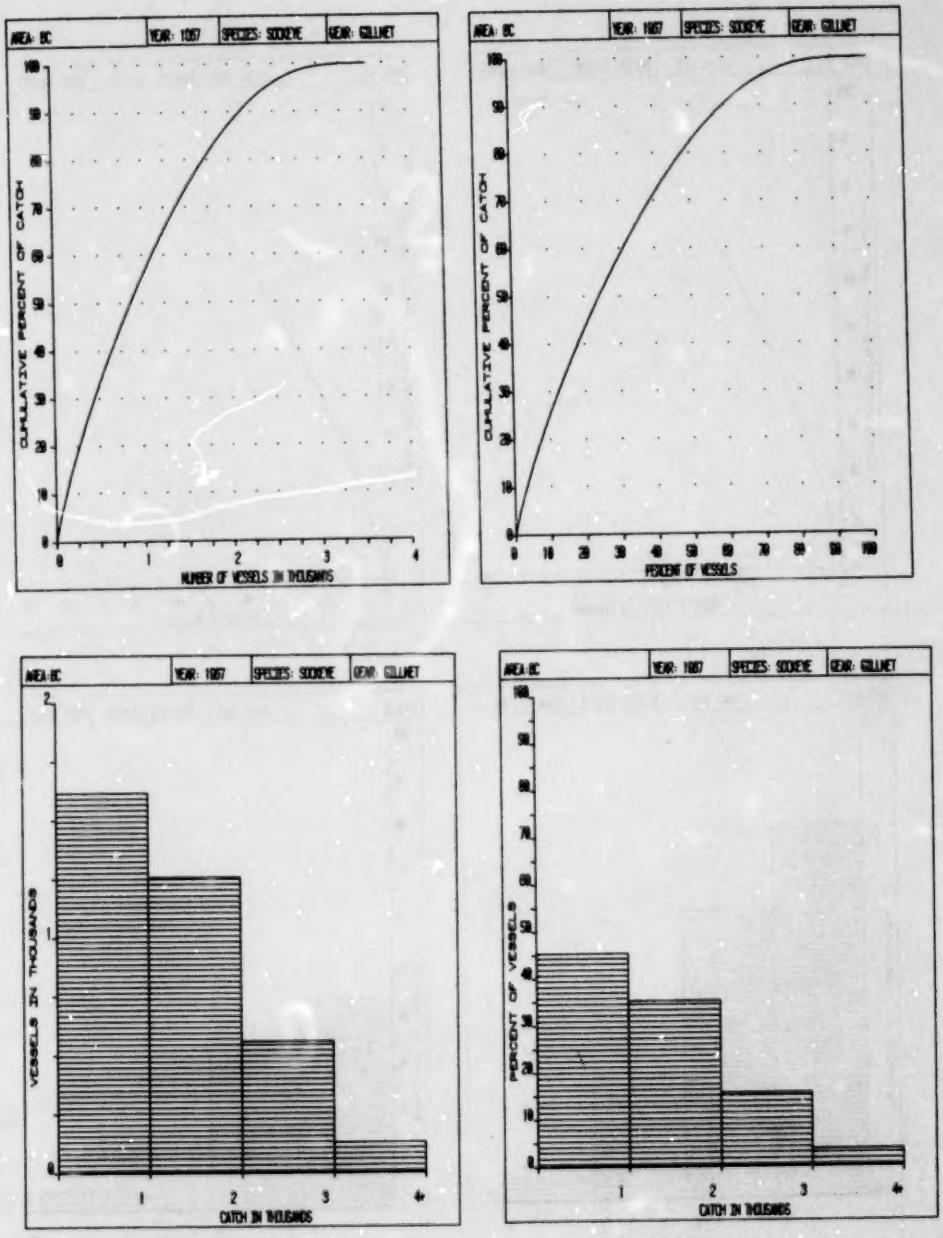

Fig. A1. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1967.

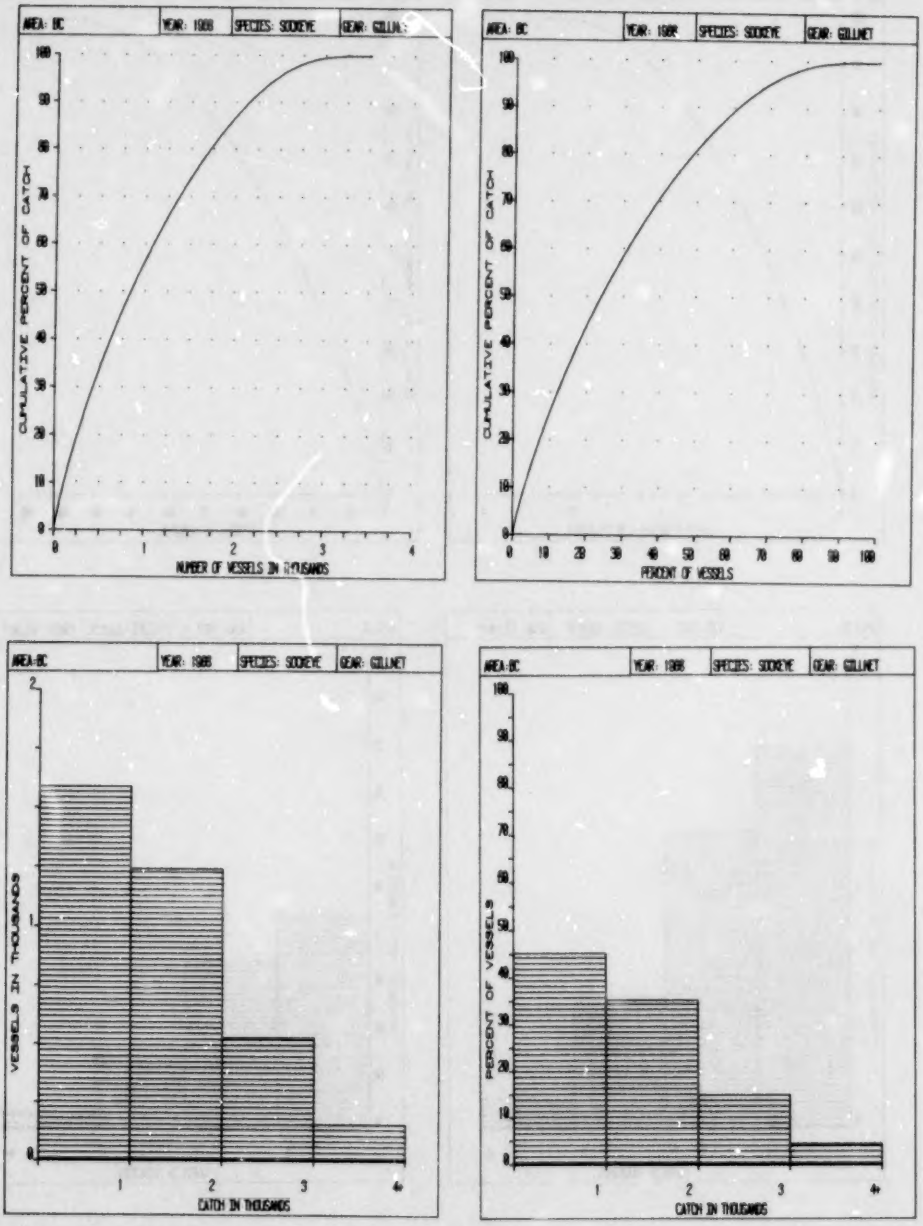

Fig. A2. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1968.

Fig. A3. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1969.

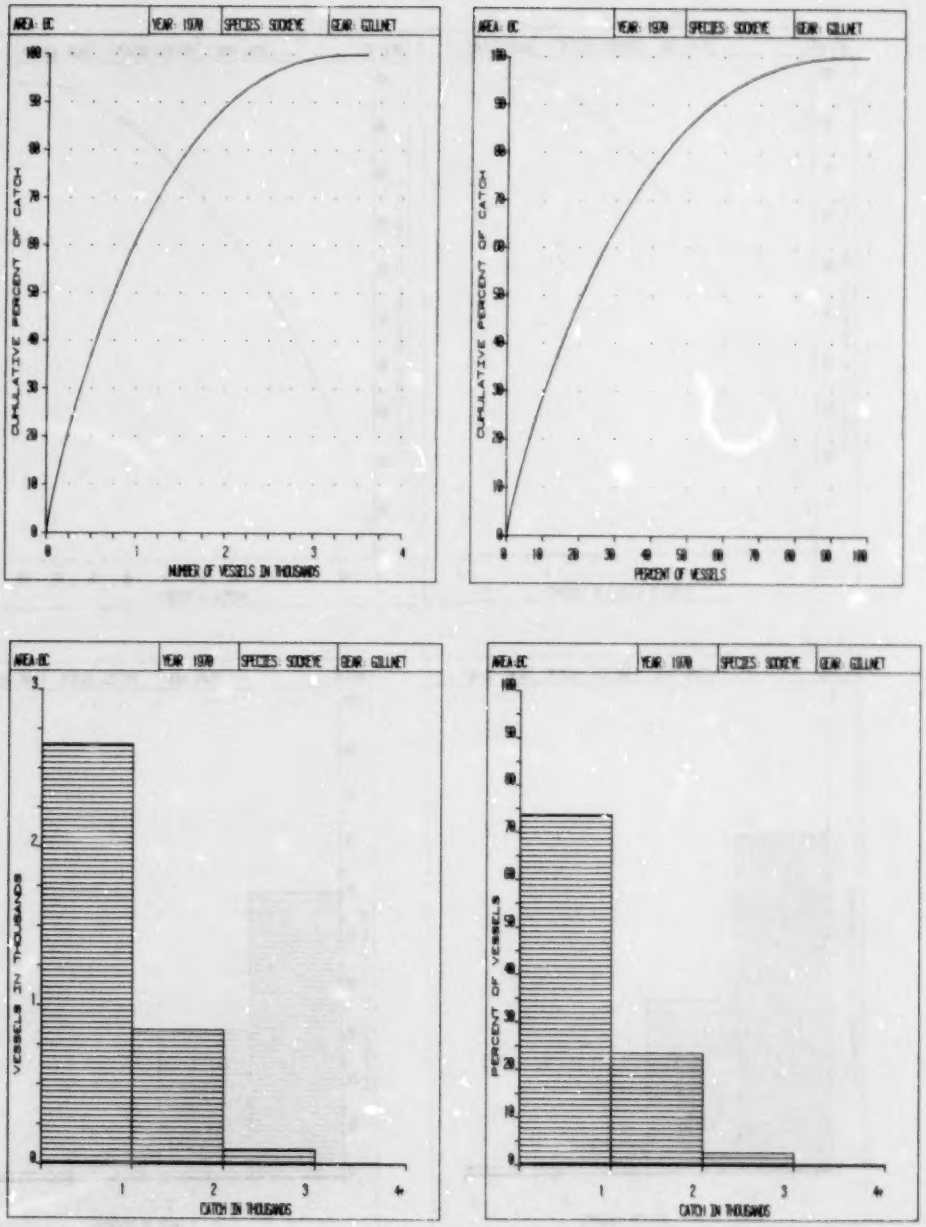

Fig. A4. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1970.

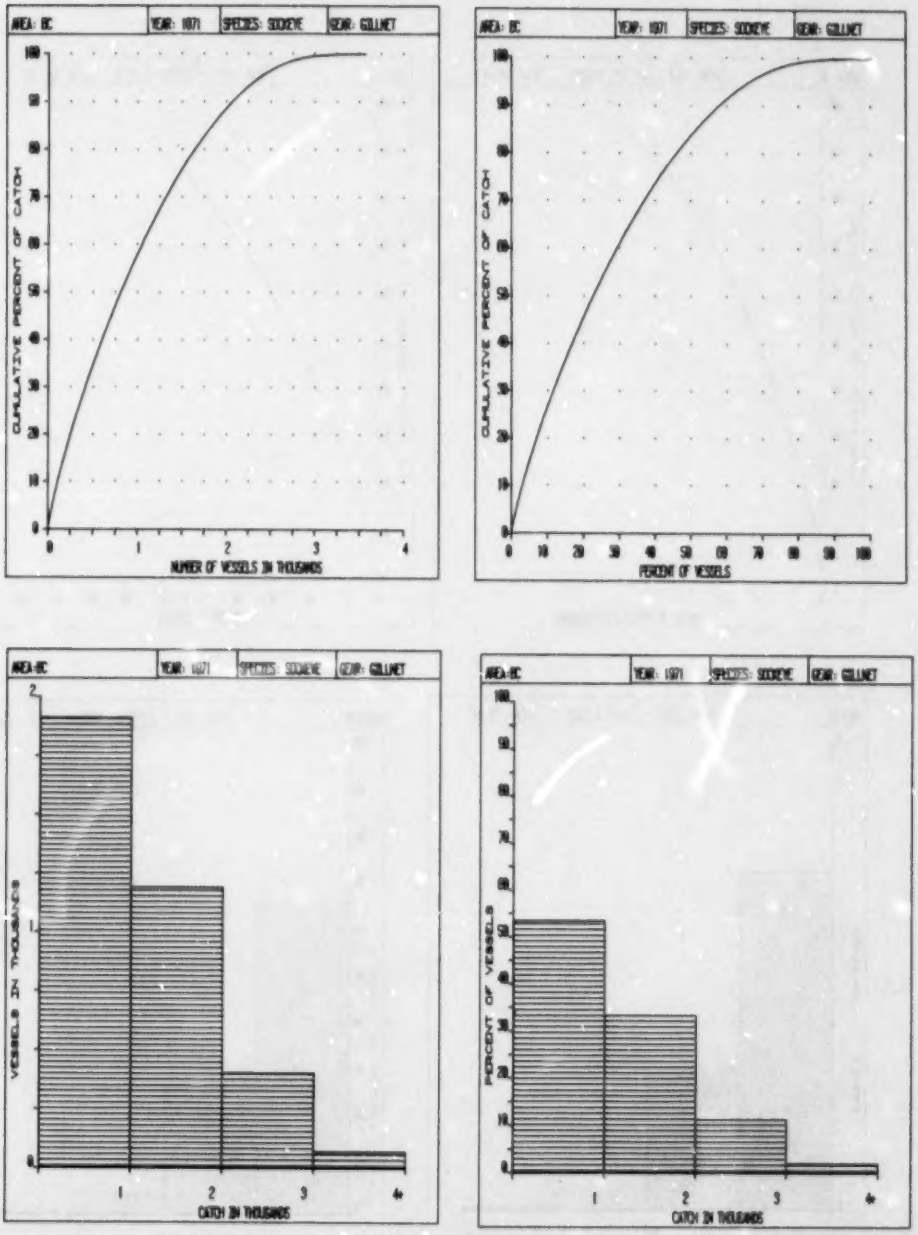

Fig. A5. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1971.

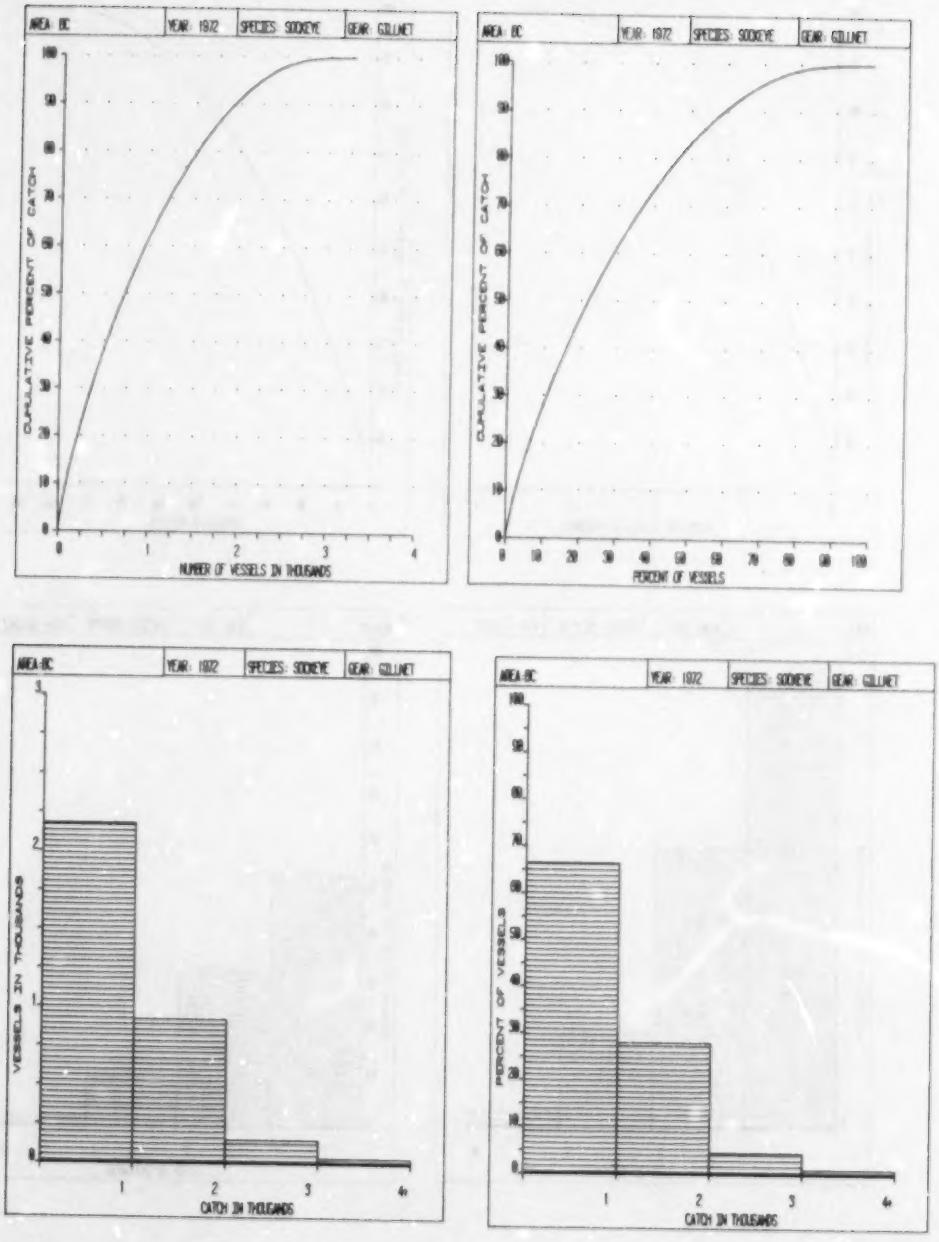

Fig. A6. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1972.

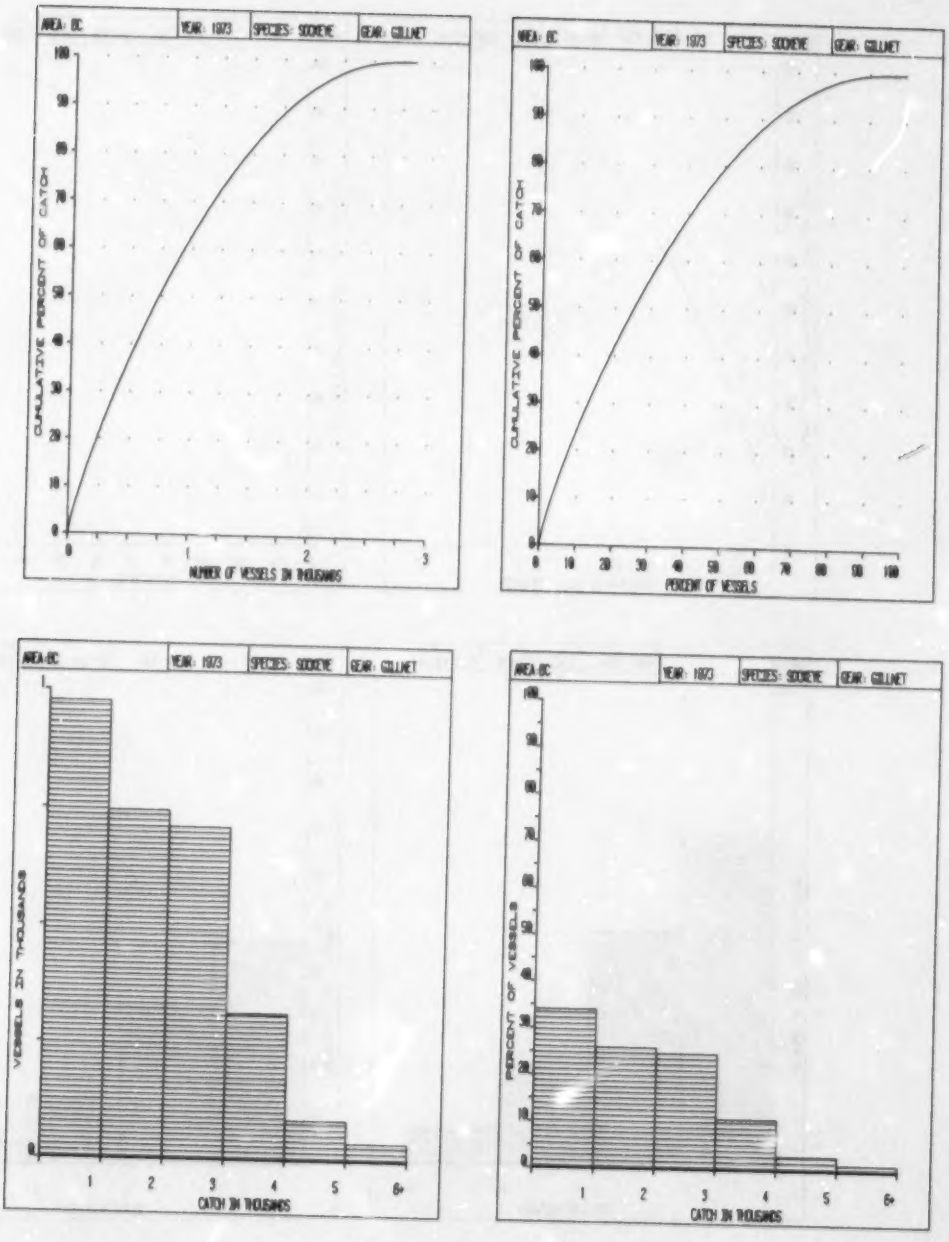

Fig. A7. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1973.

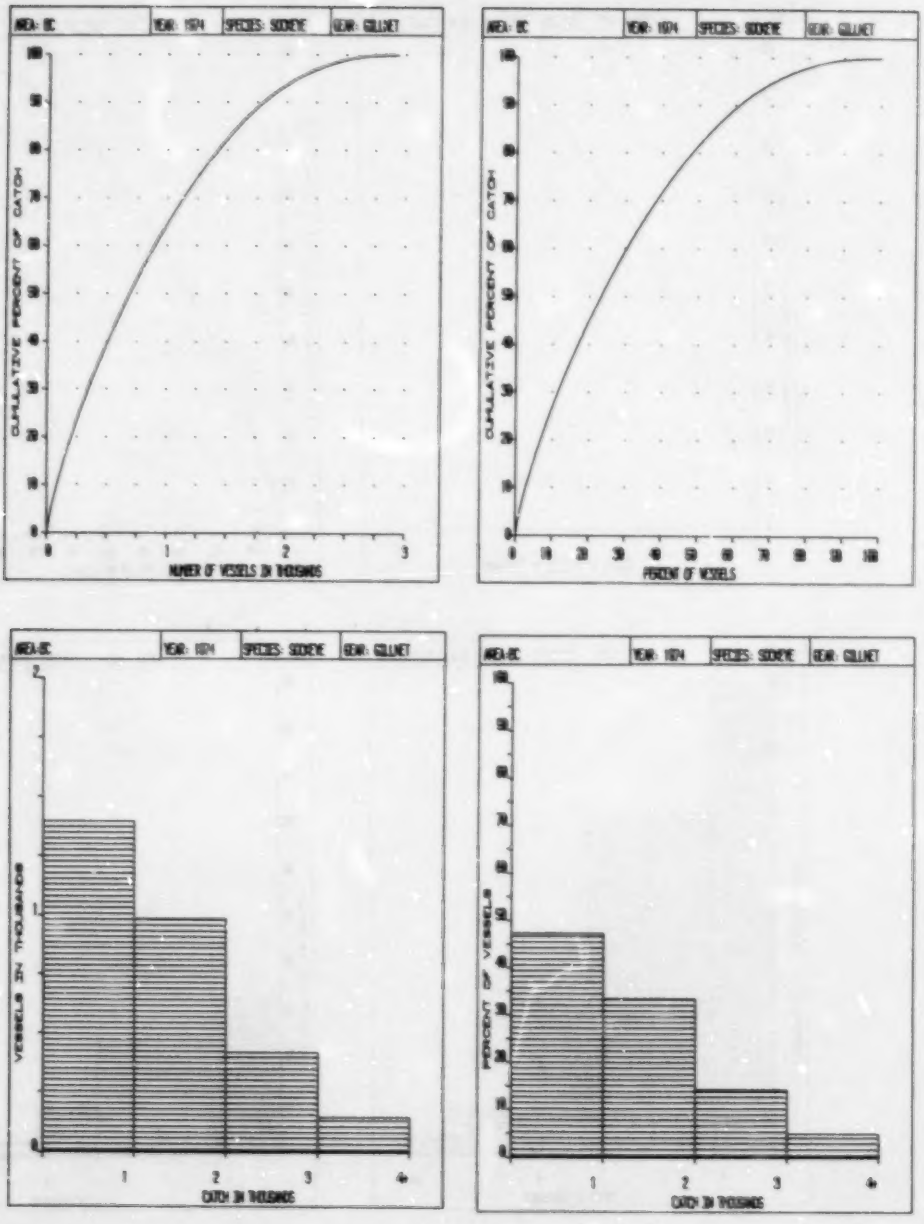

Fig. A8. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1974.

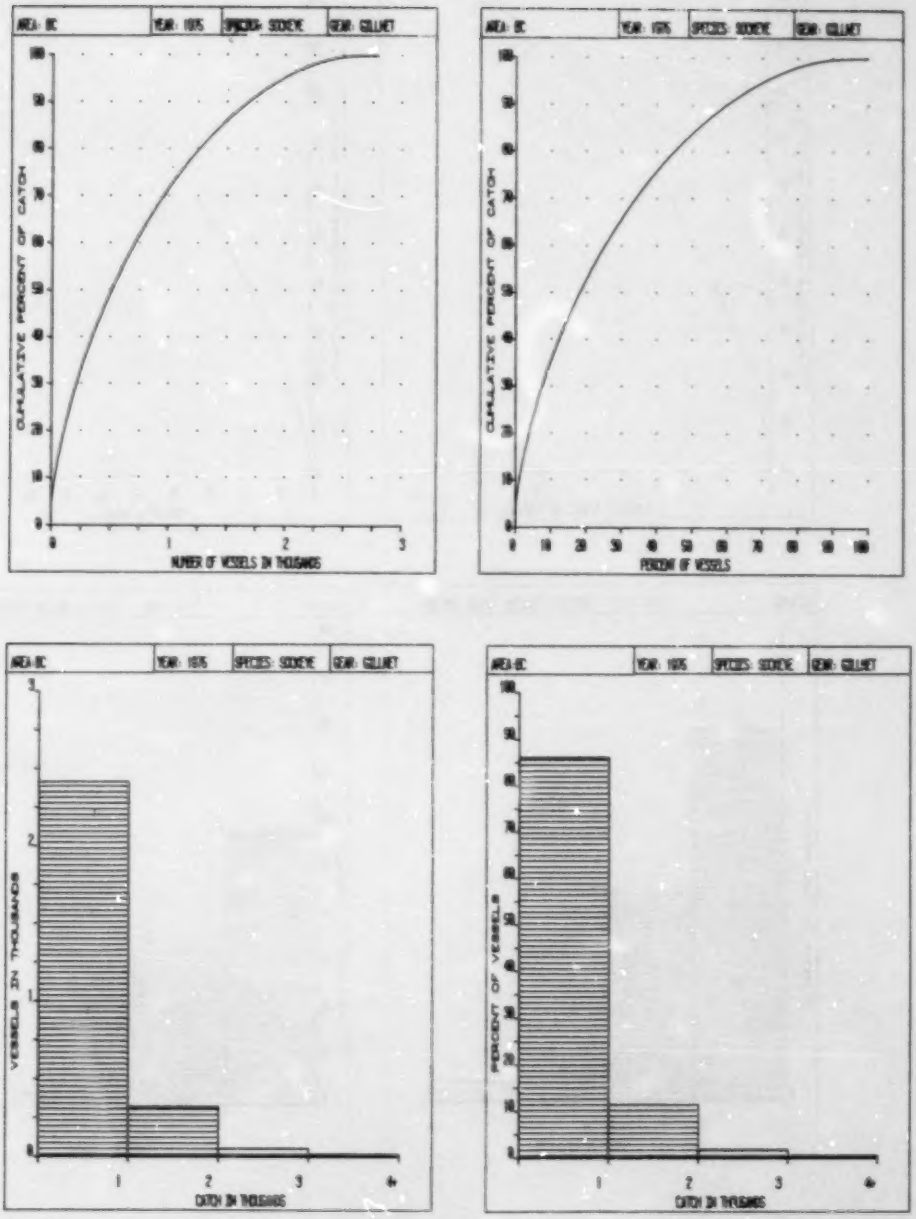

Fig. A9. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1975.

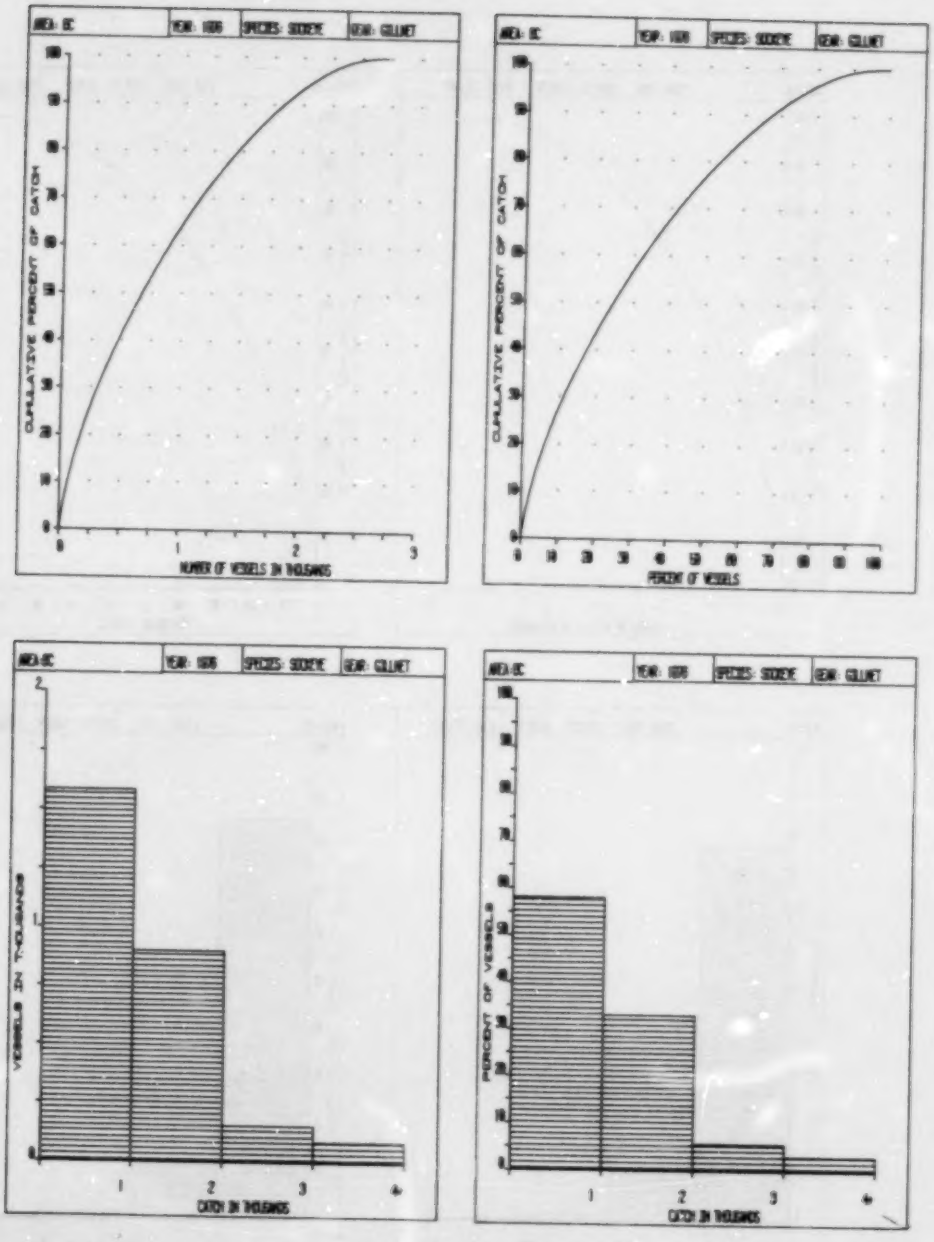

Fig. A10. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1976.

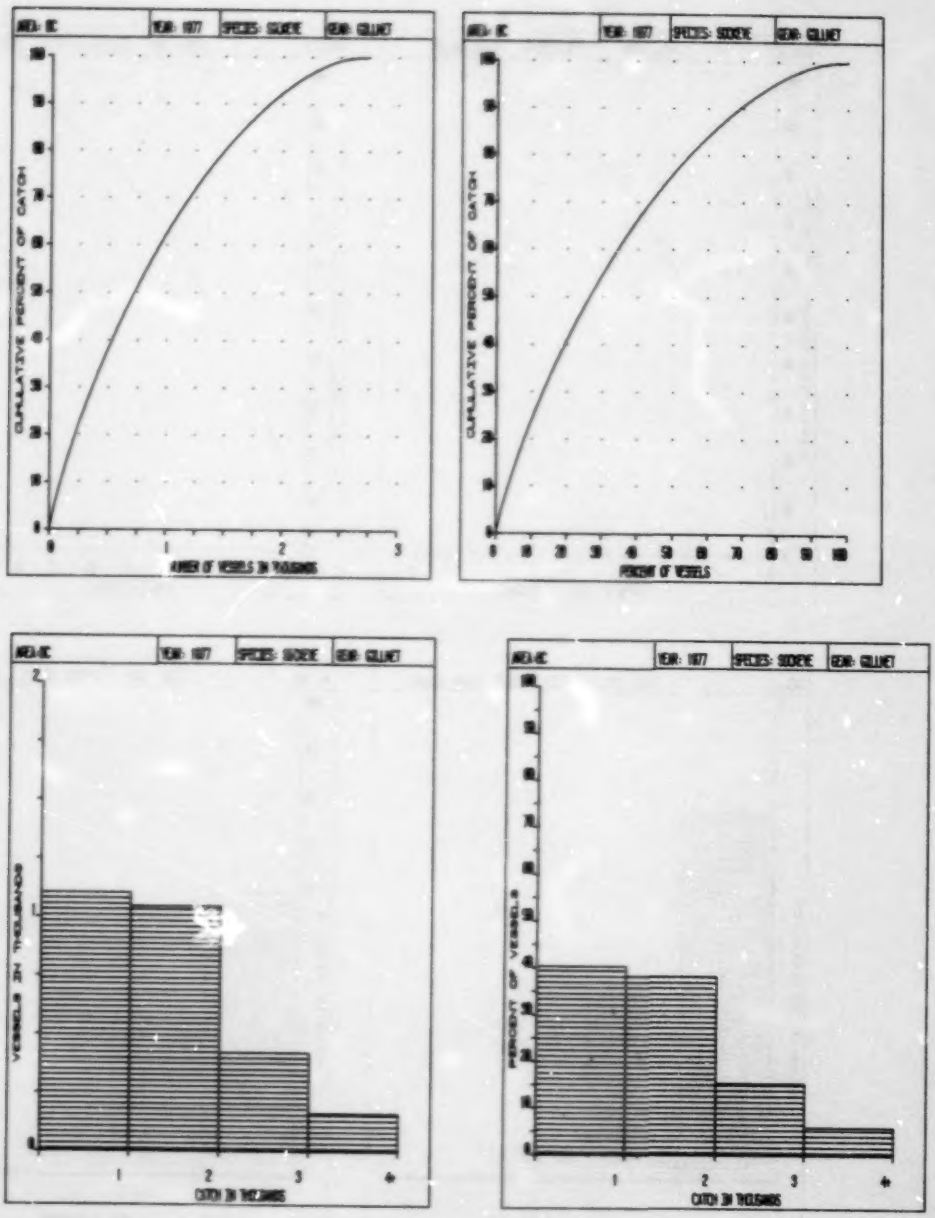

Fig. A11. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1977.

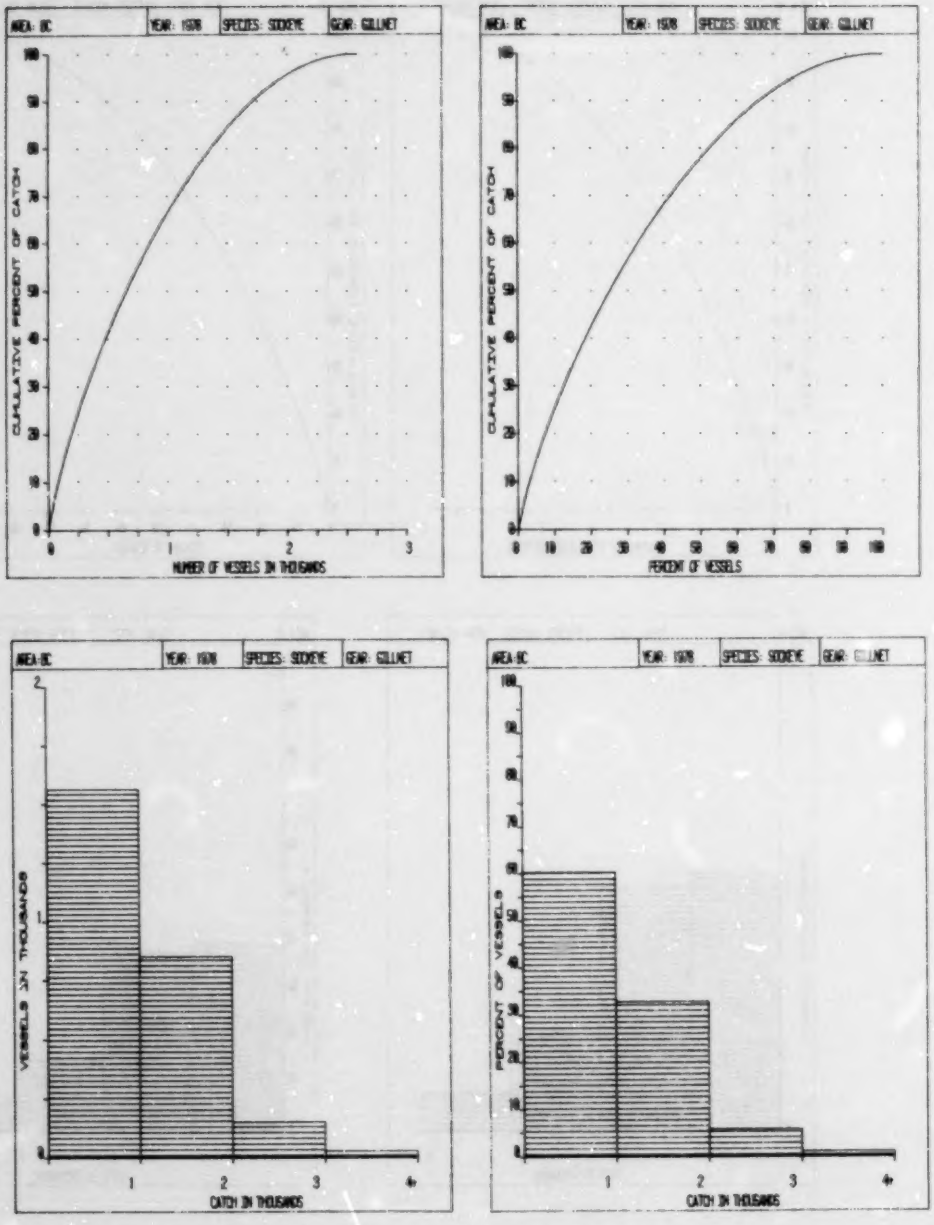

Fig. A12. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1978.

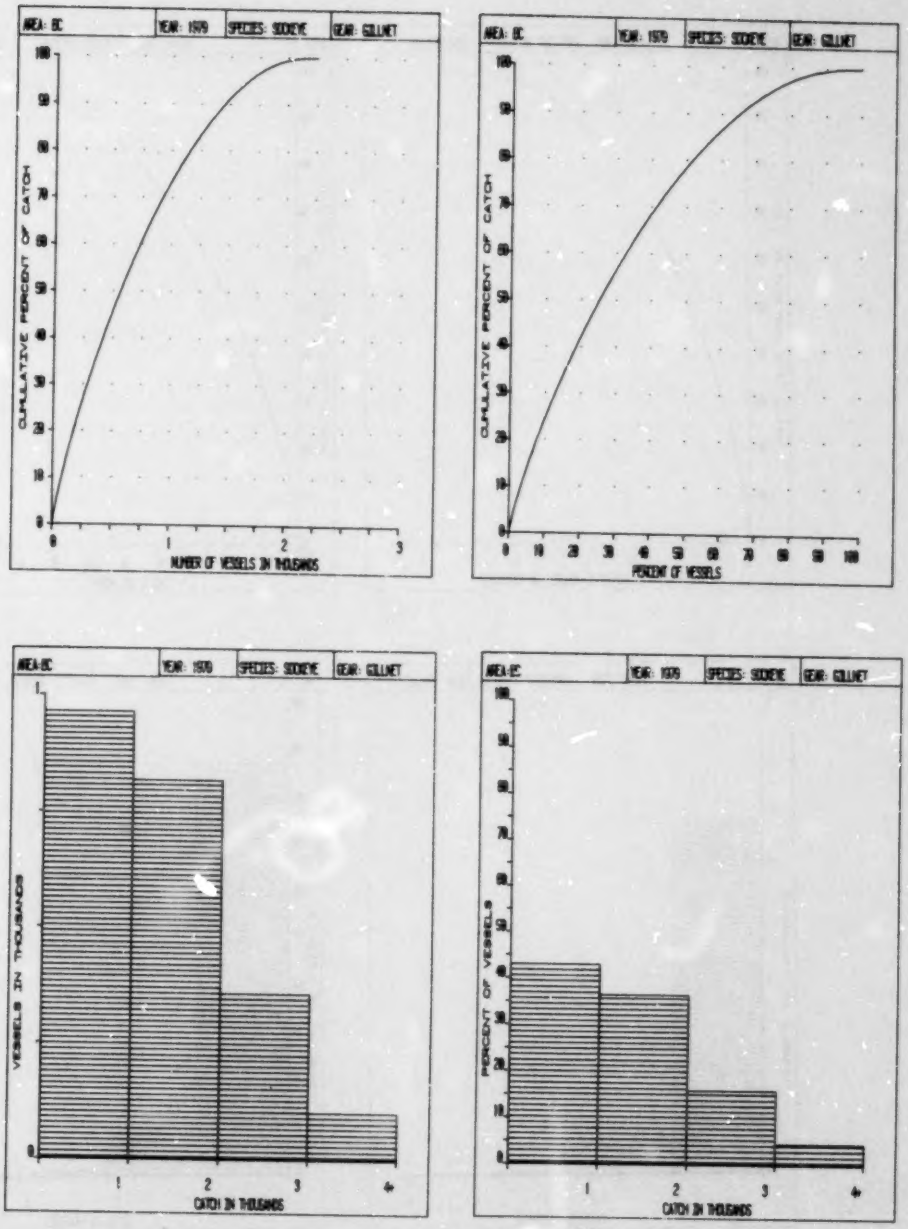

Fig. A13. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1979.

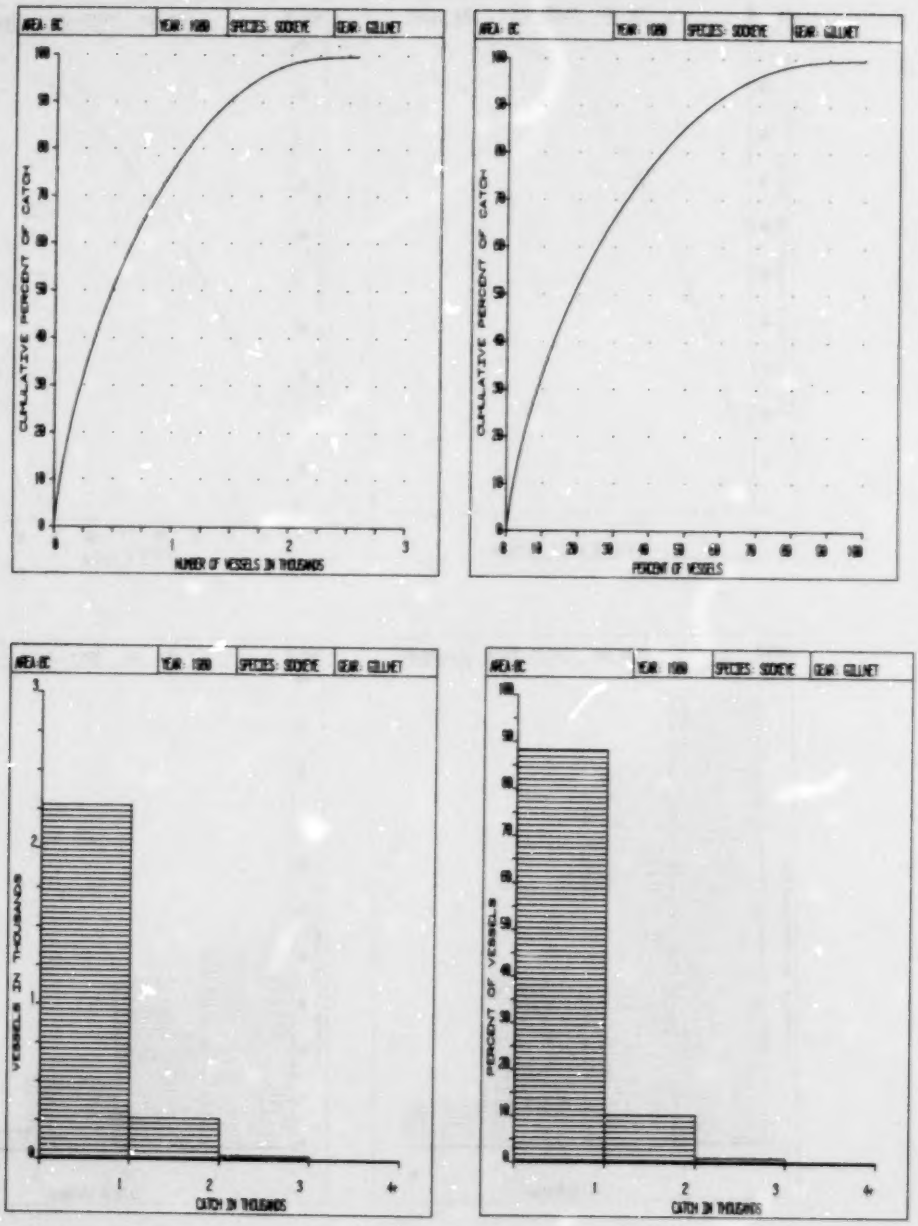

Fig. A14. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1980.

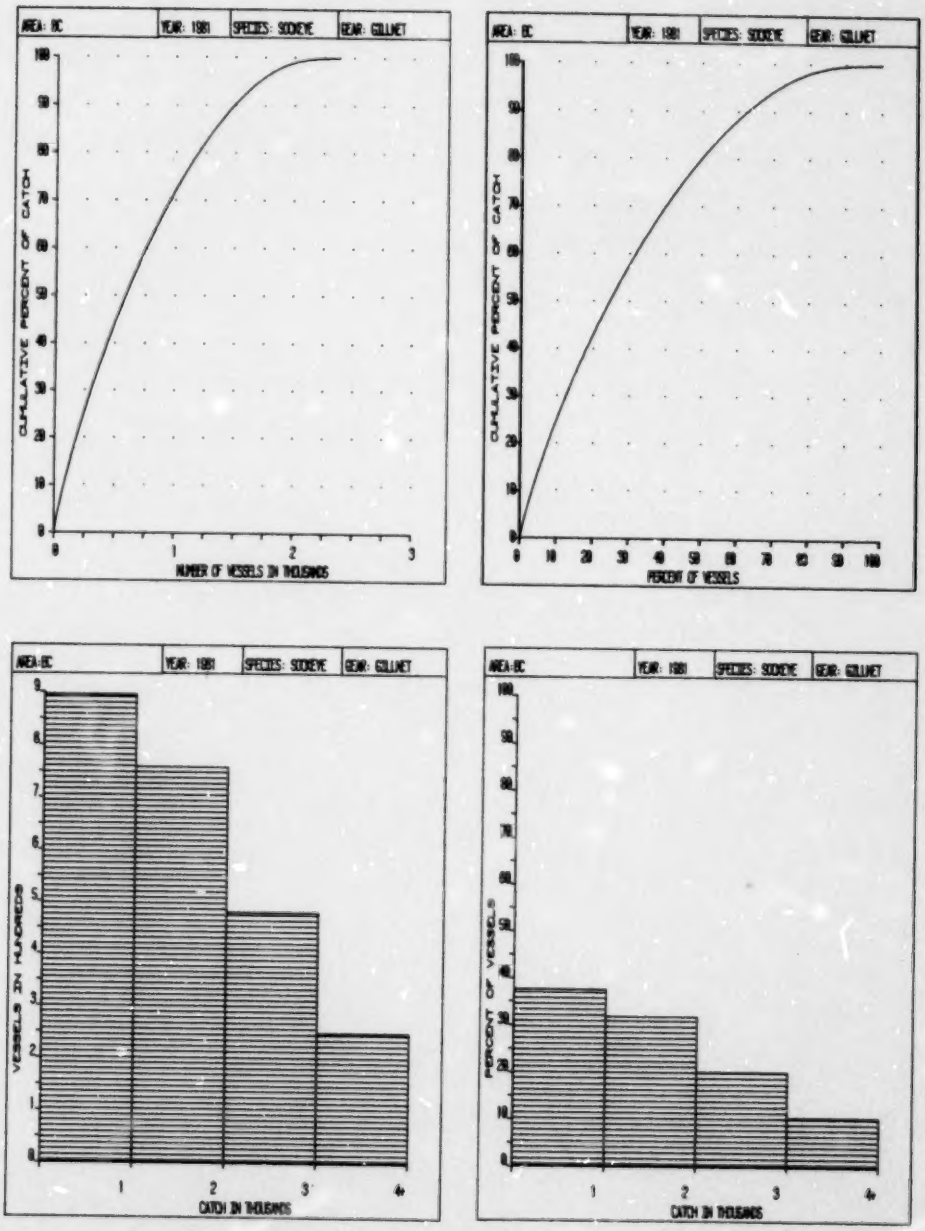

Fig. A15. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used gillnets and participated in the fishery, 1981.

APPENDIX B

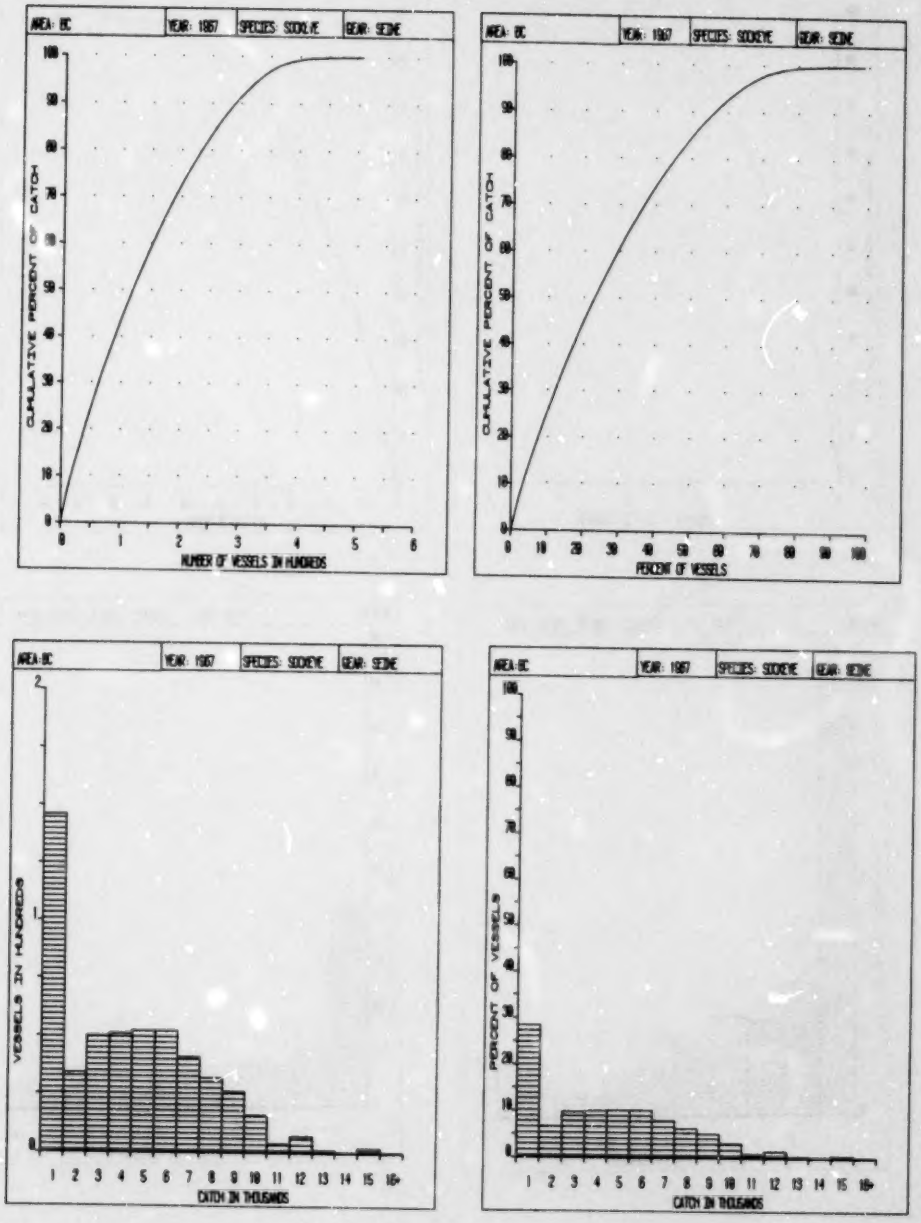

Fig. B1. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1967.

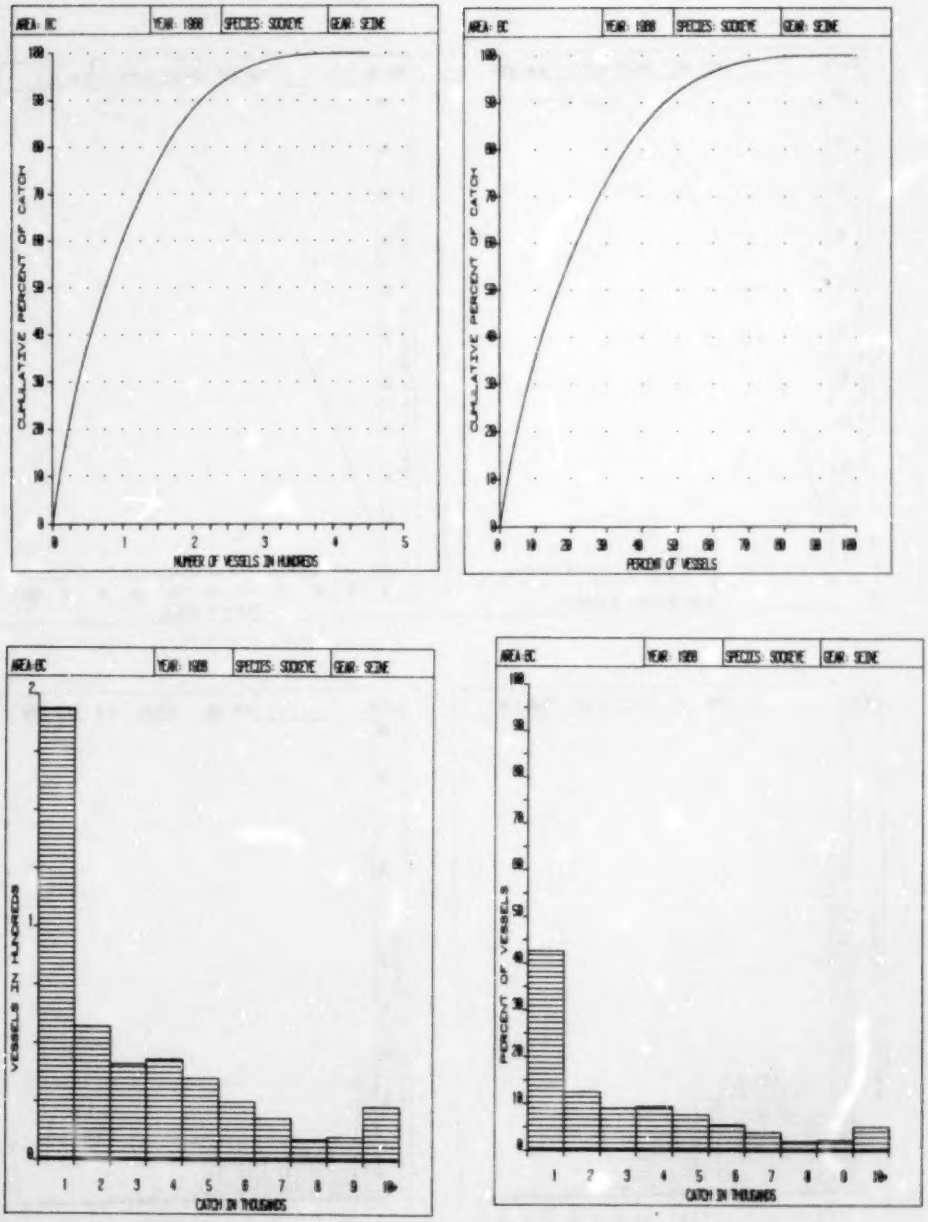

Fig. B2. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1968.

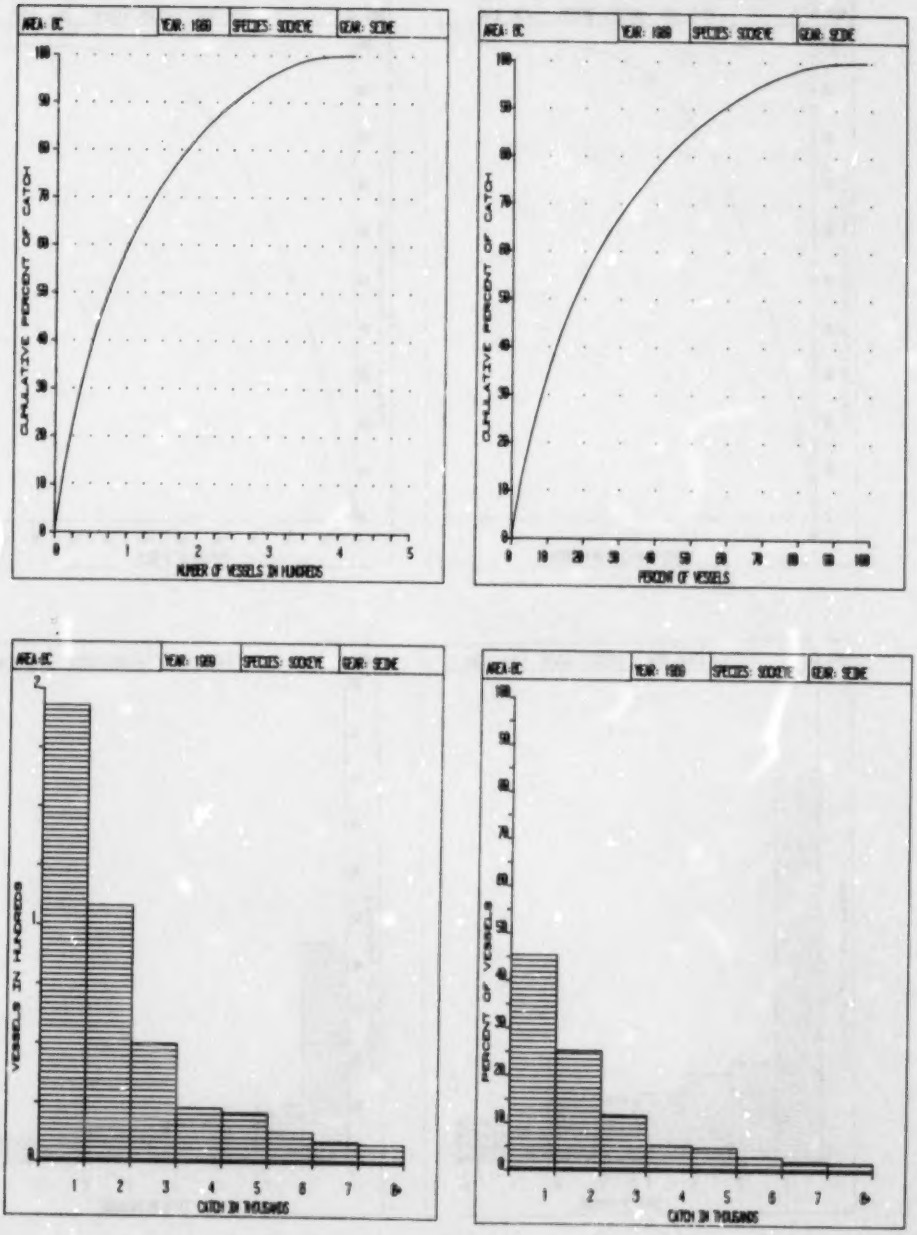

Fig. B3. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1969.

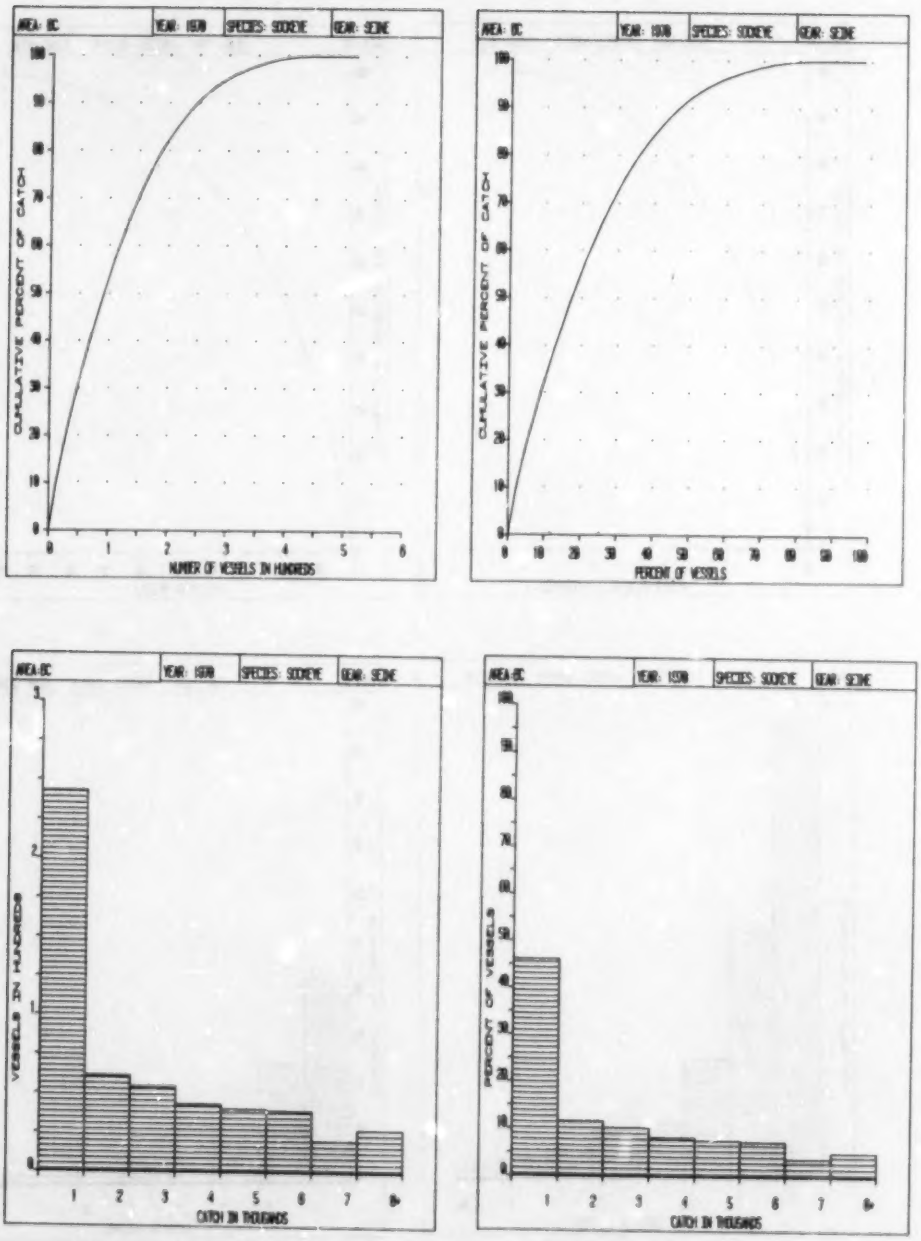

Fig. B4. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1970.

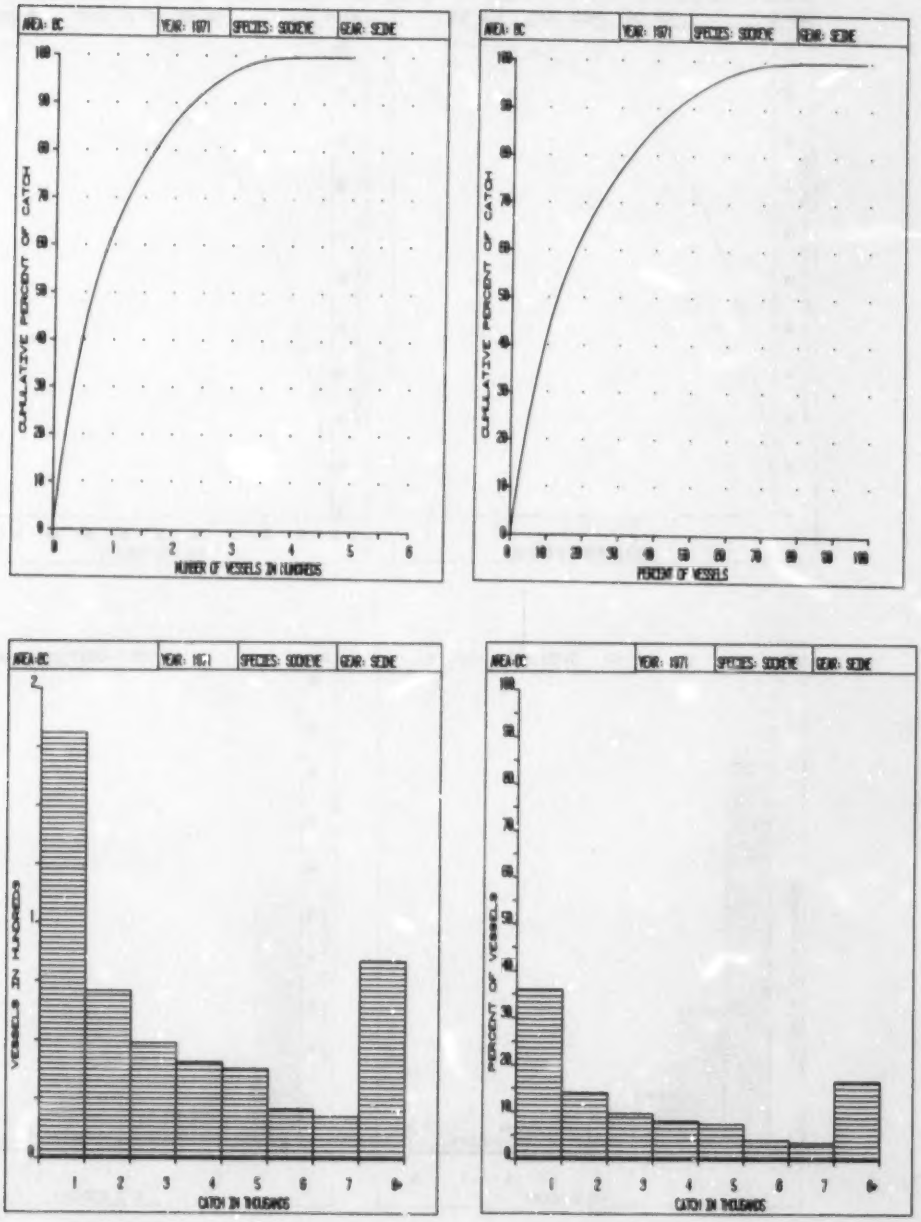

Fig. B5. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1971.

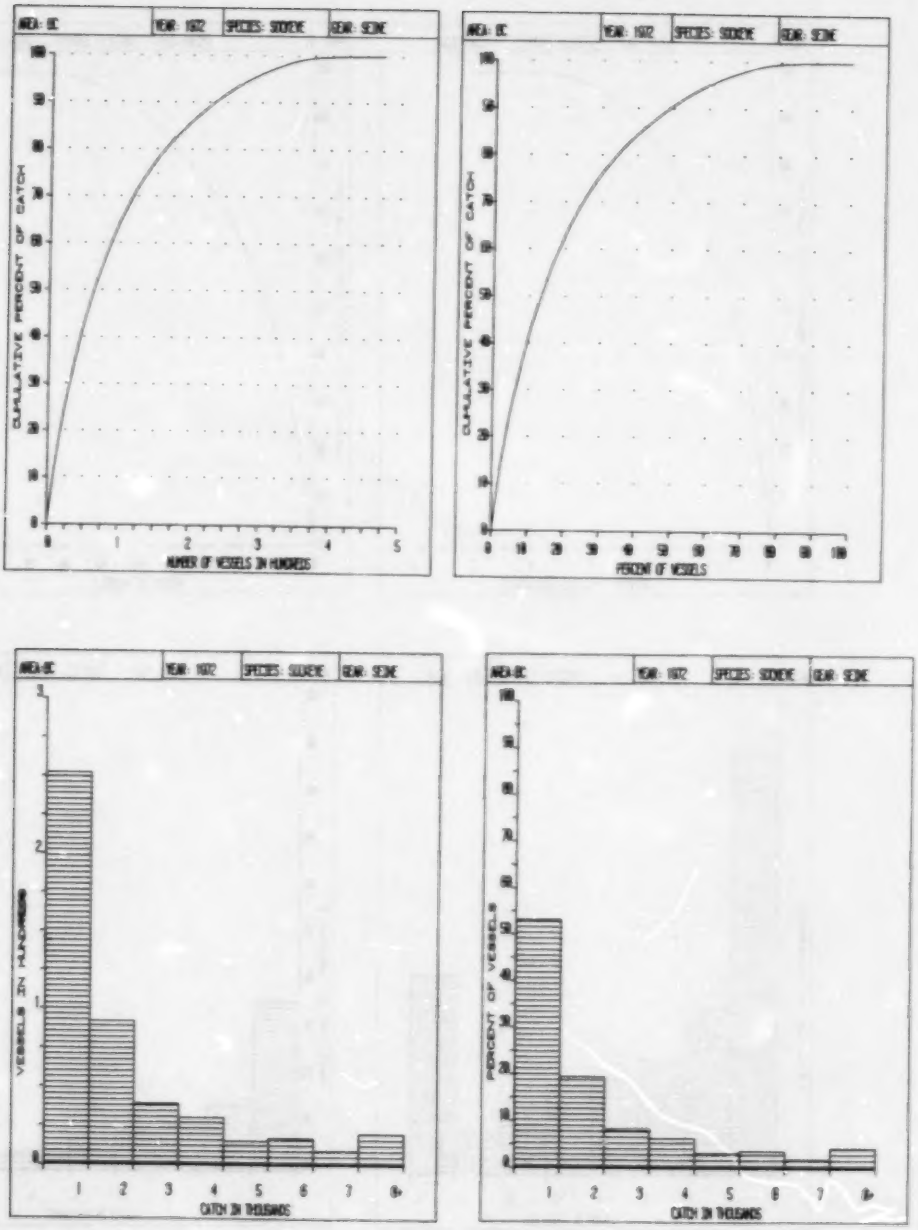

Fig. 86. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1972.

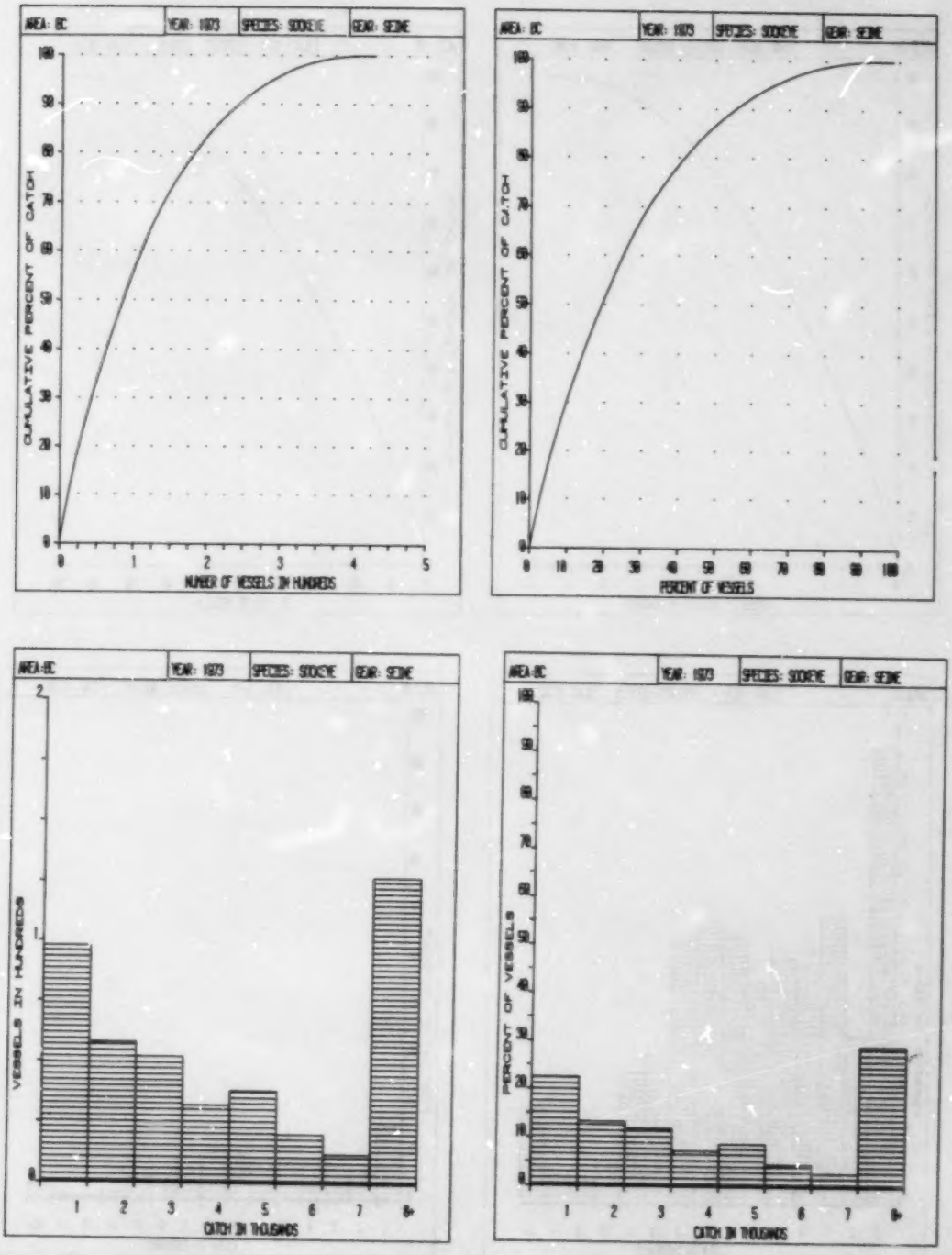

Fig. 87. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1973.

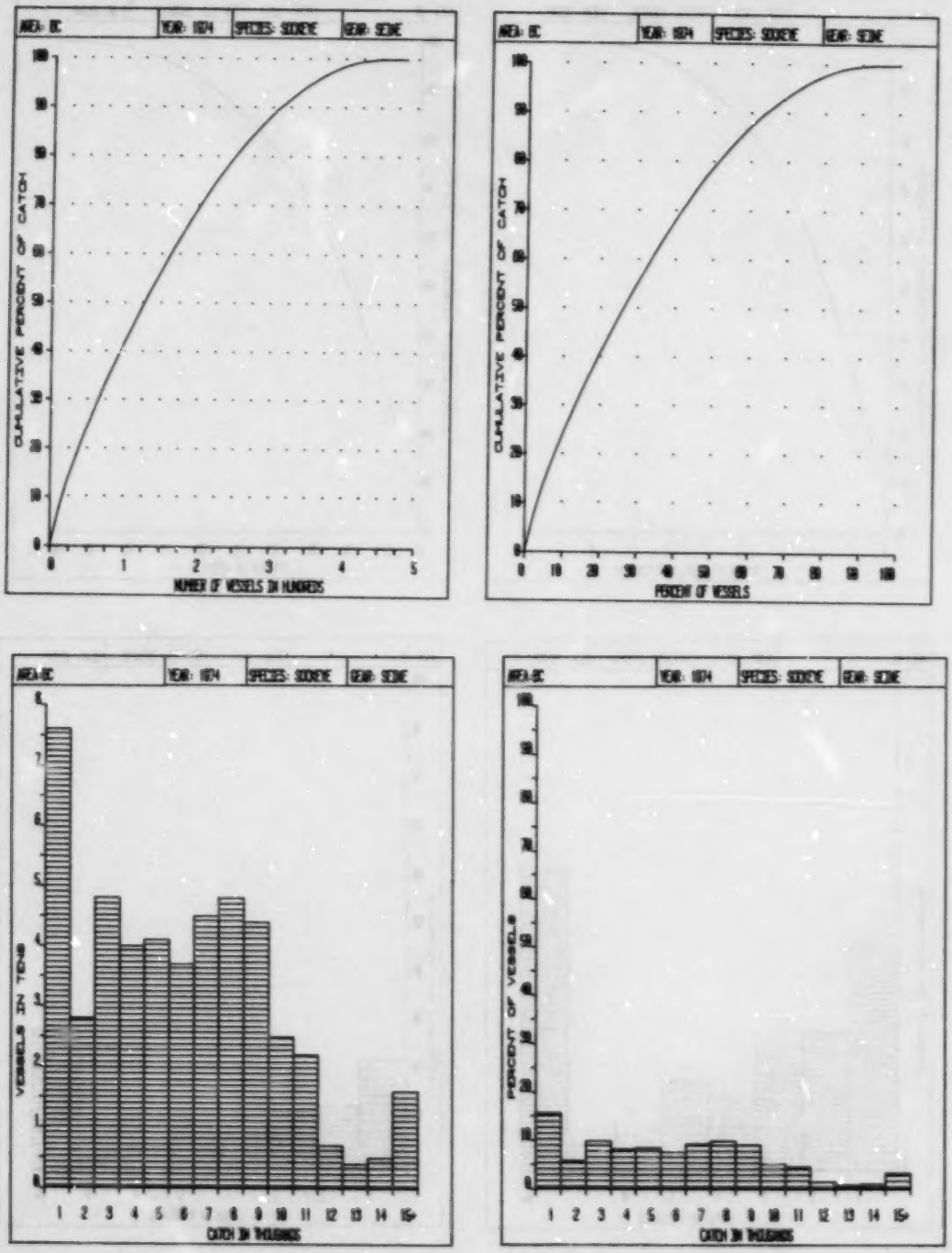

Fig. 88. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1974.

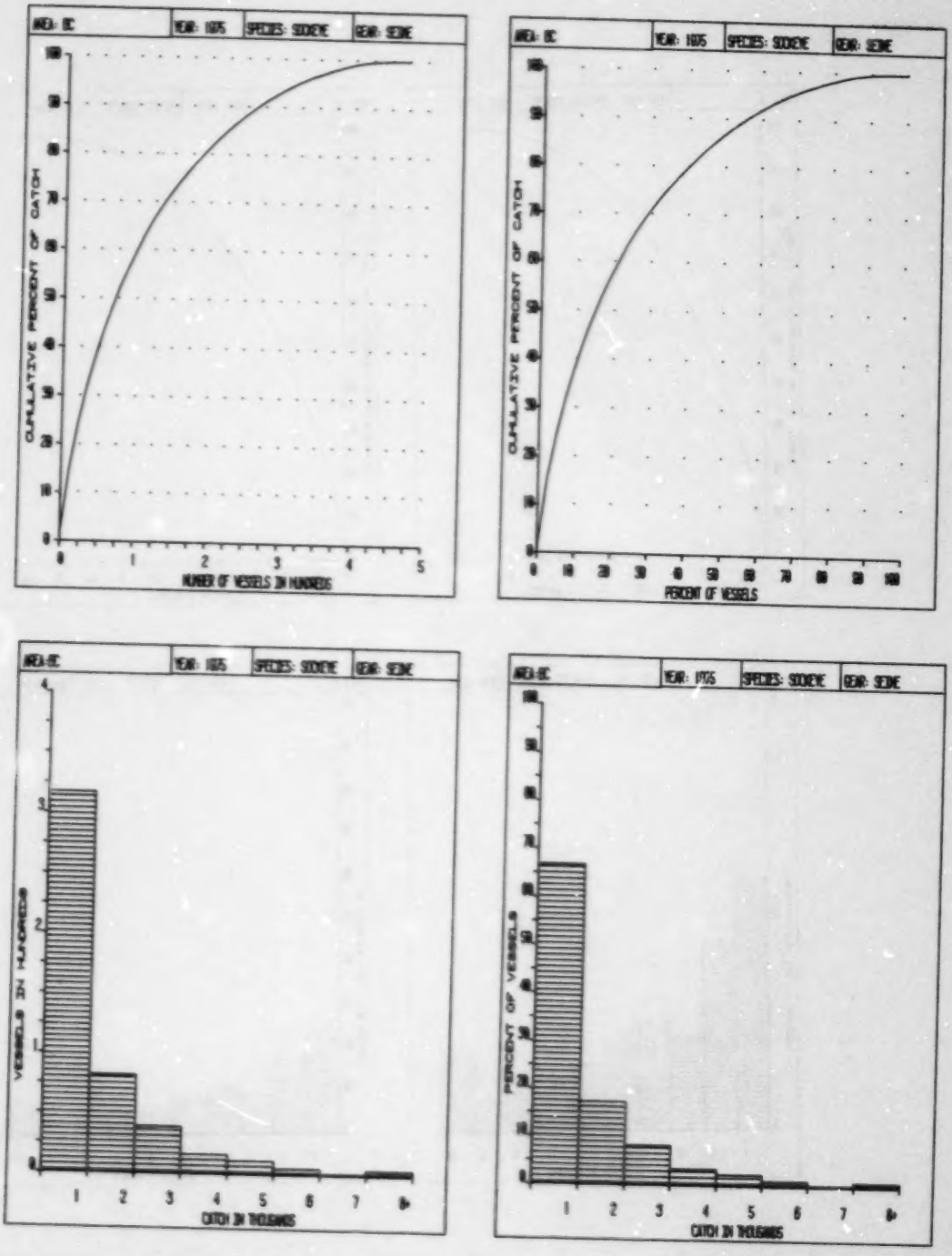

Fig. 89. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1975.

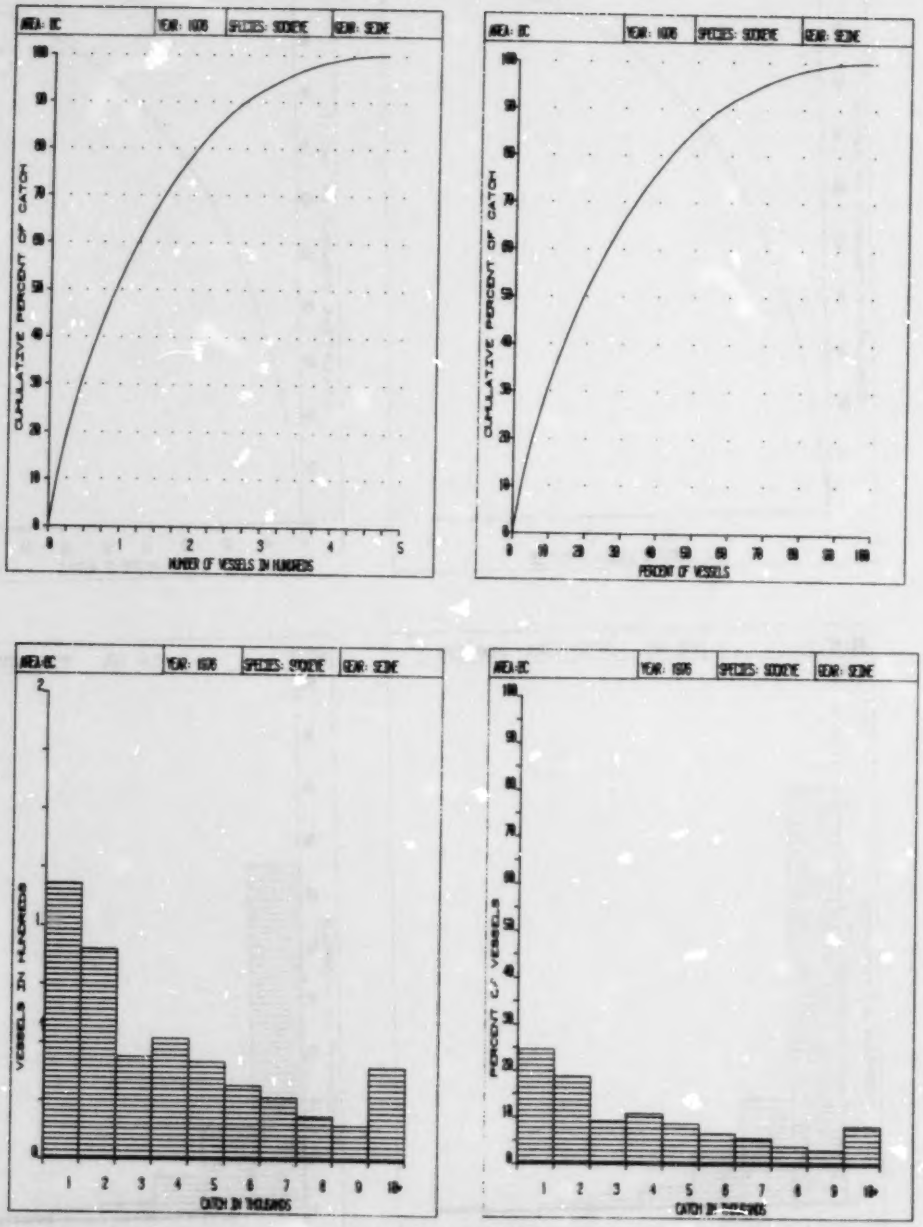

Fig. B10. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1976.

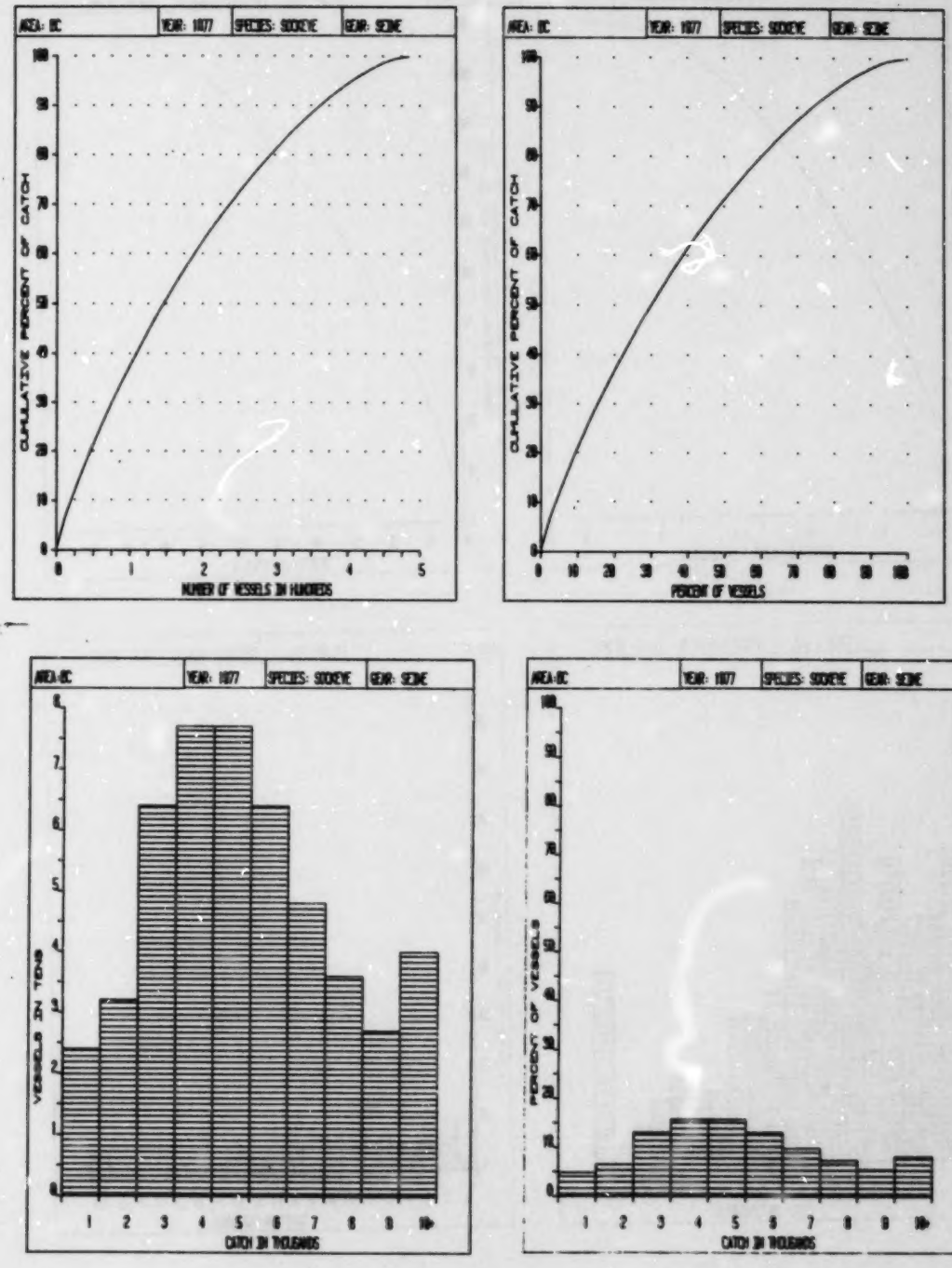

Fig. B11. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1977.

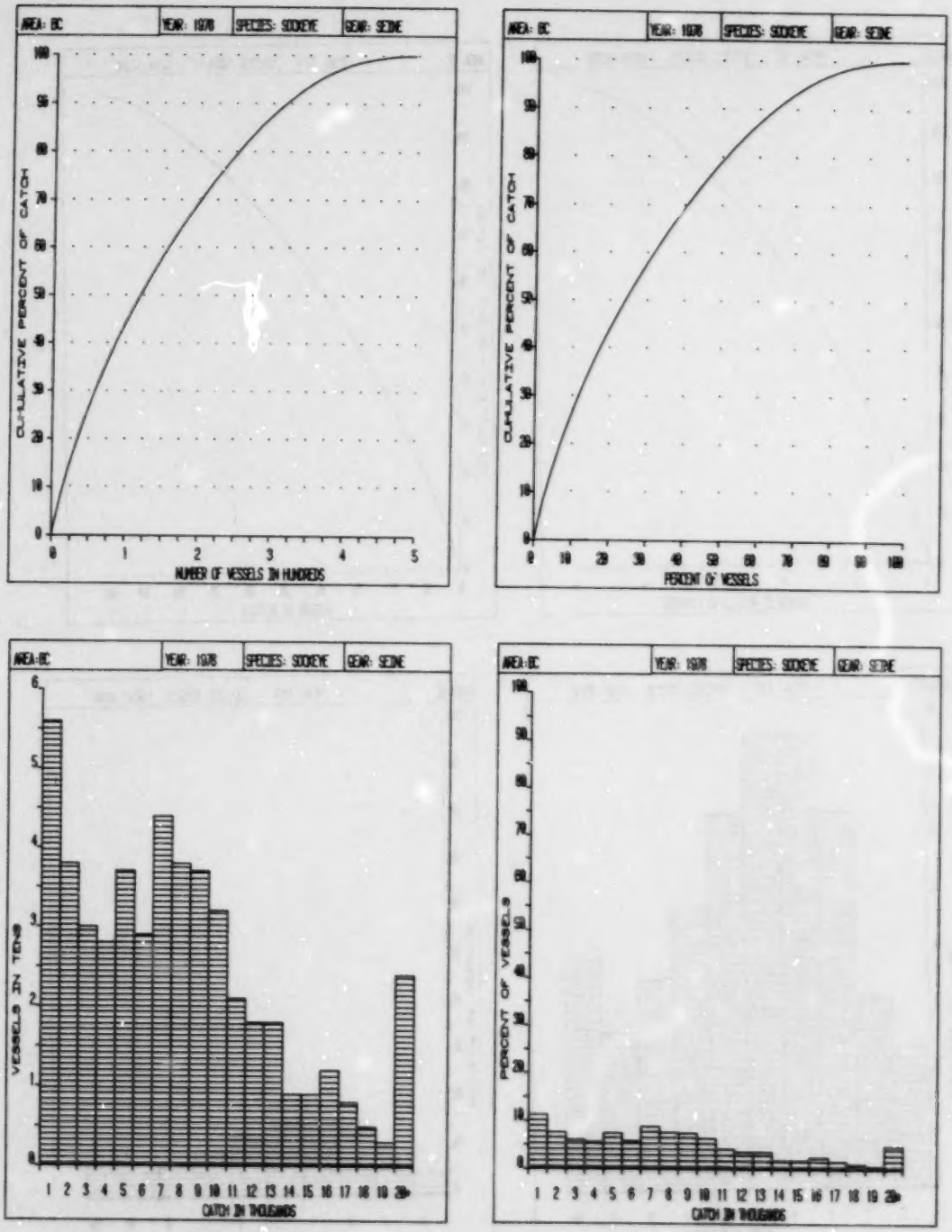

Fig. B12. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1978.

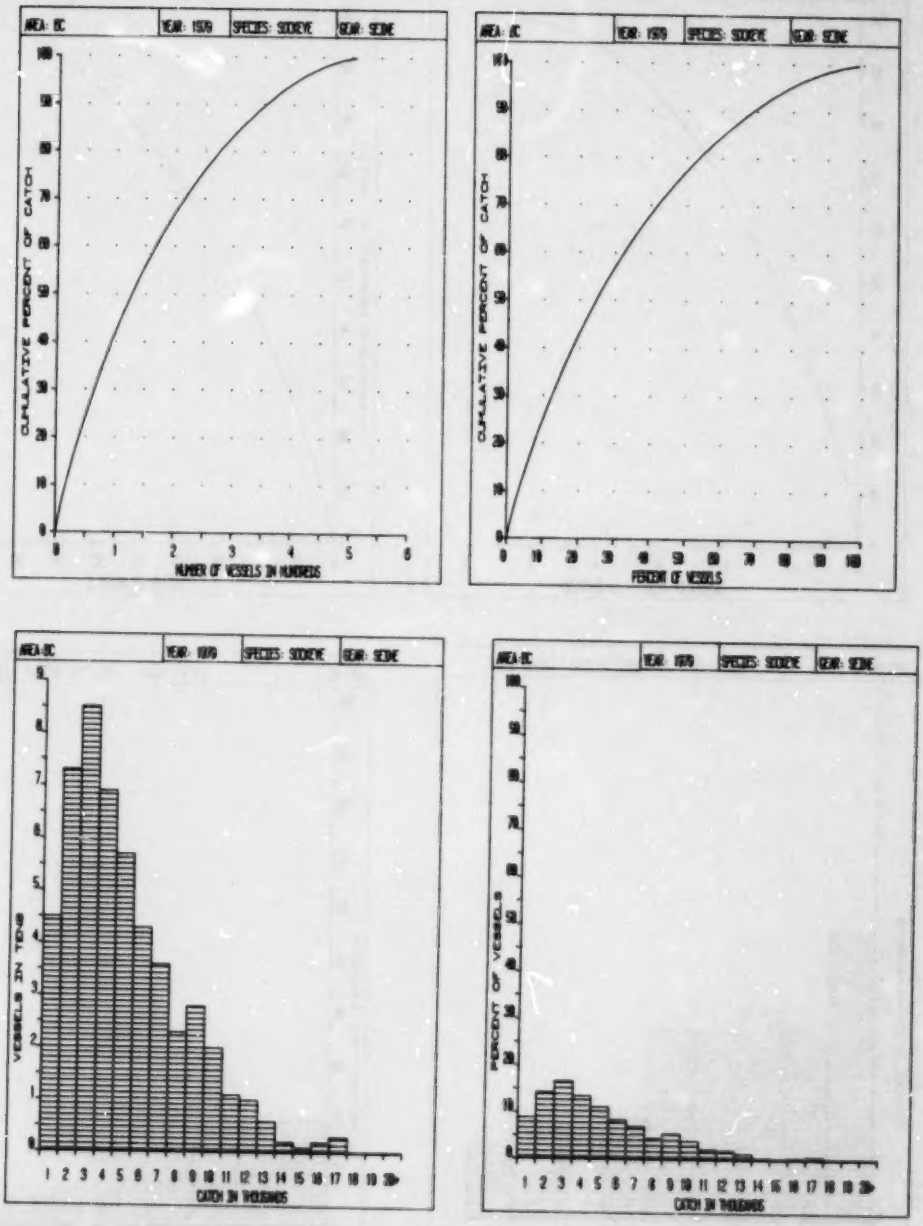

Fig. 813. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1979.

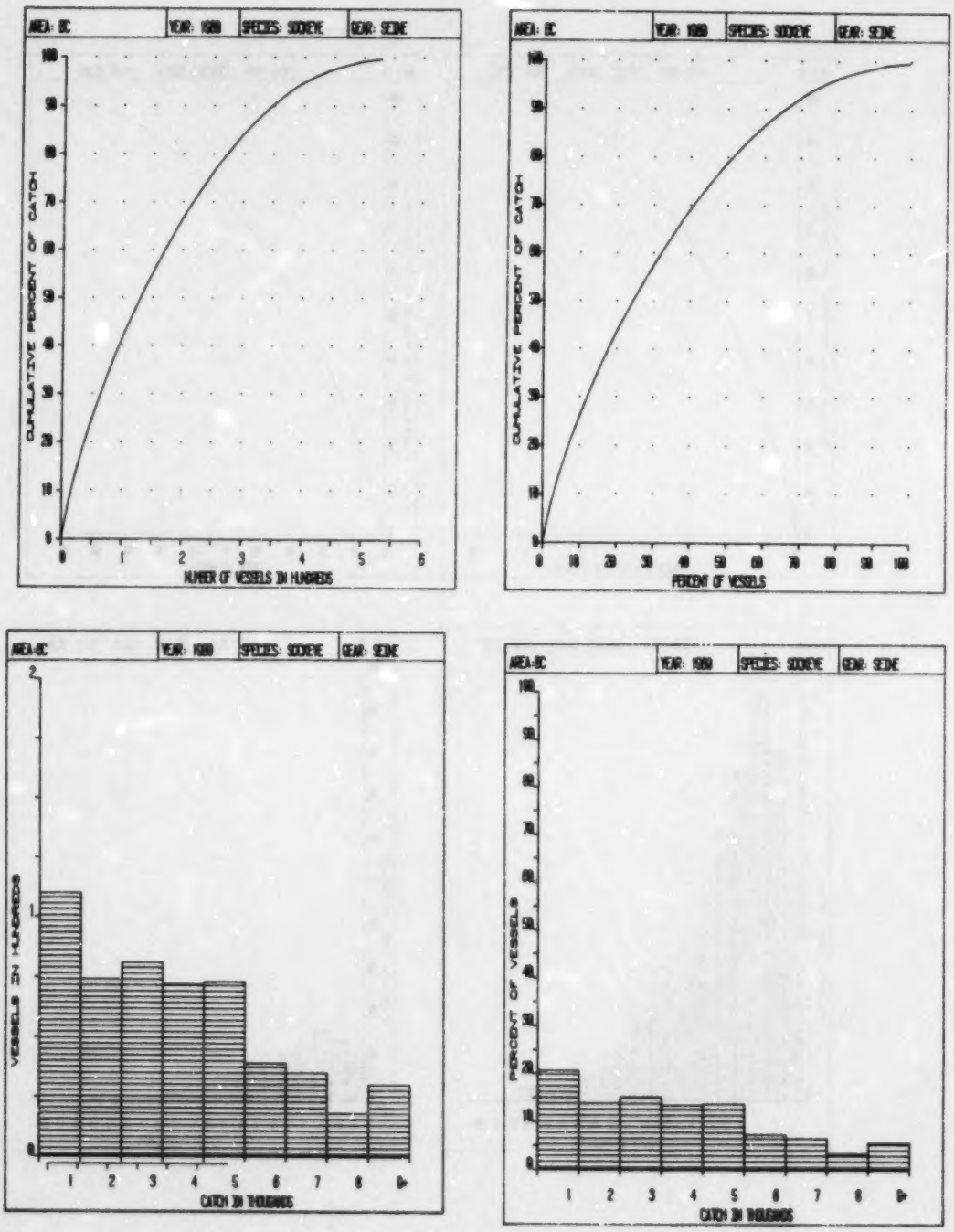

Fig. B14. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in the fishery, 1980.

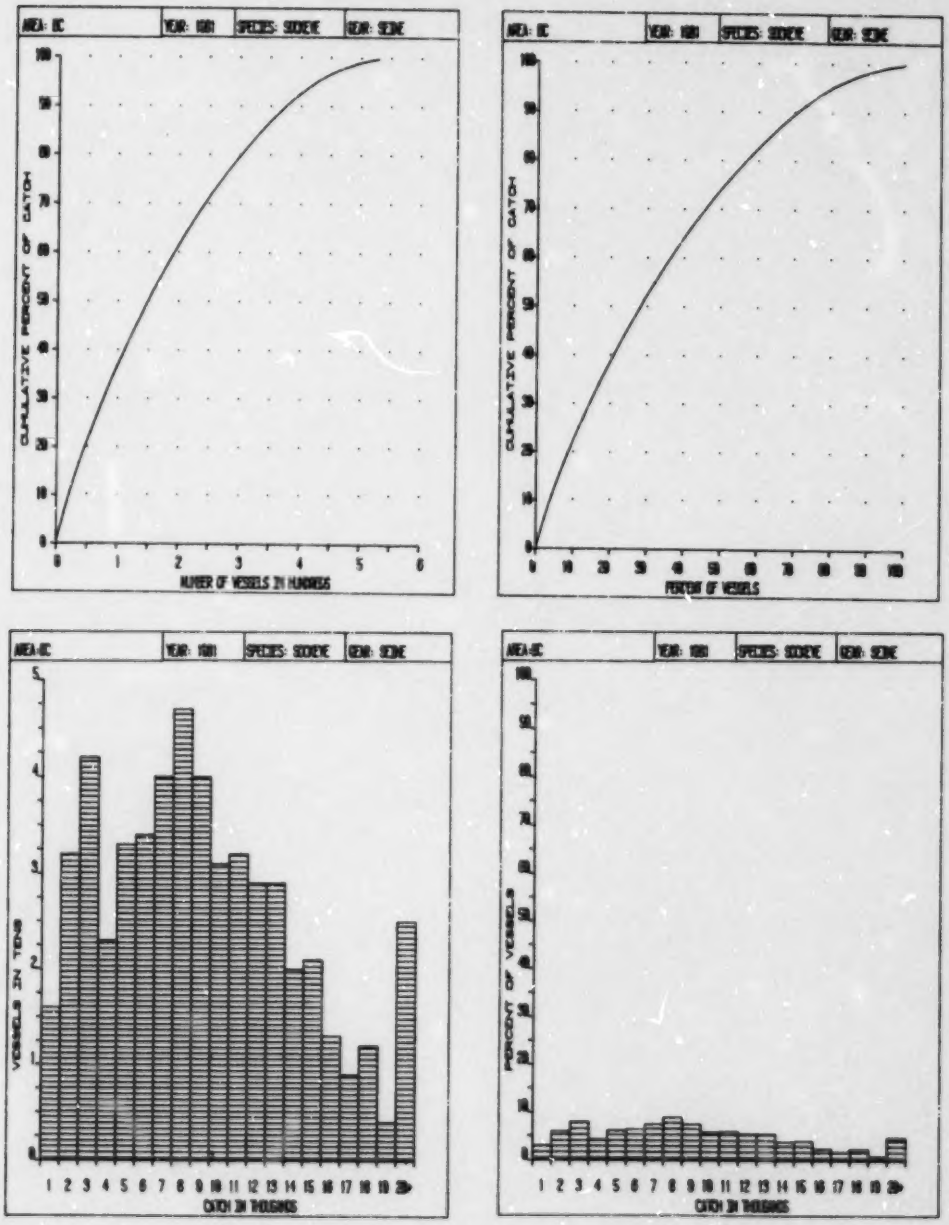

Fig. B15. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of purse seiners that participated in tne fisnery, 1981.

APPENDIX C

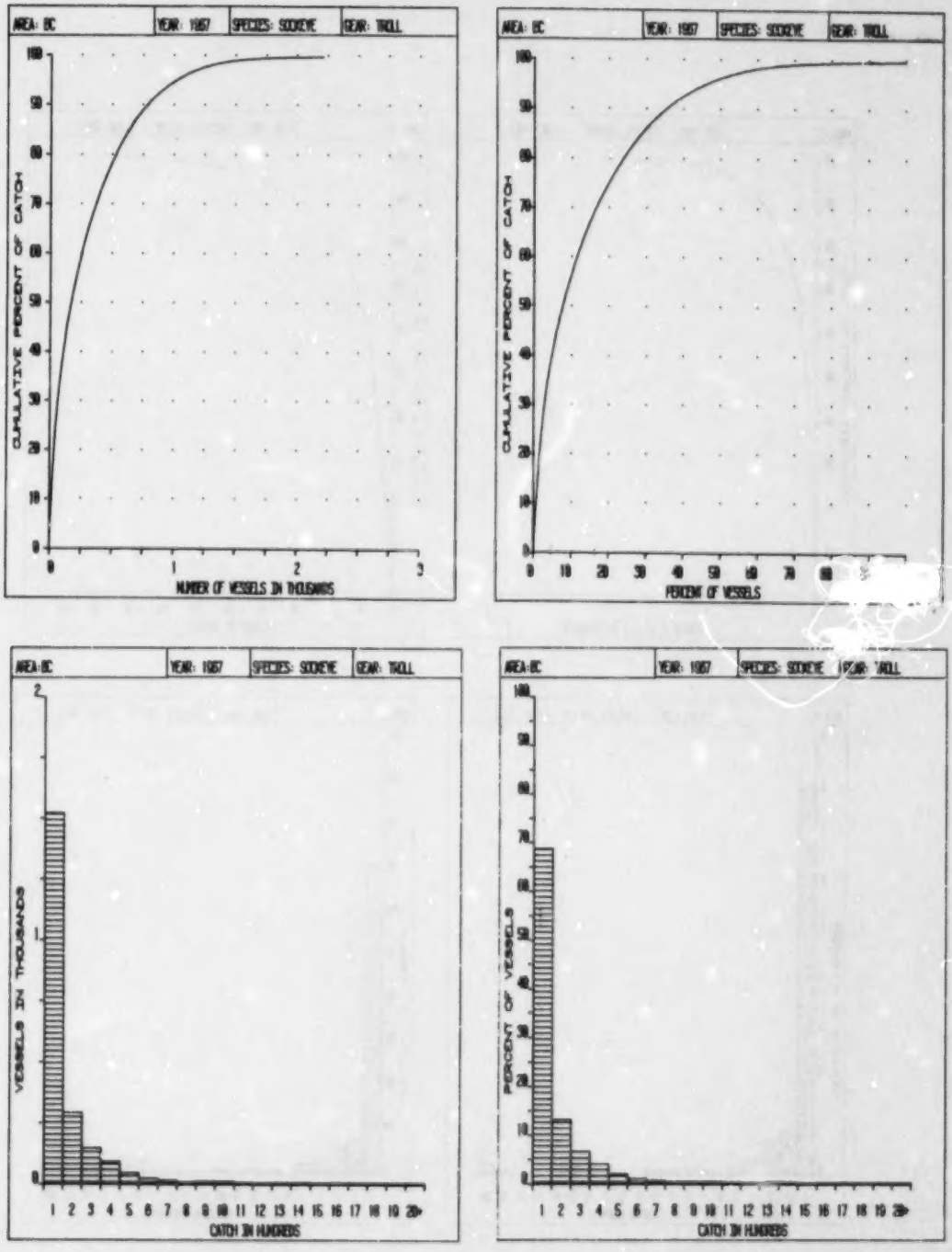

Fig. C1. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1967.

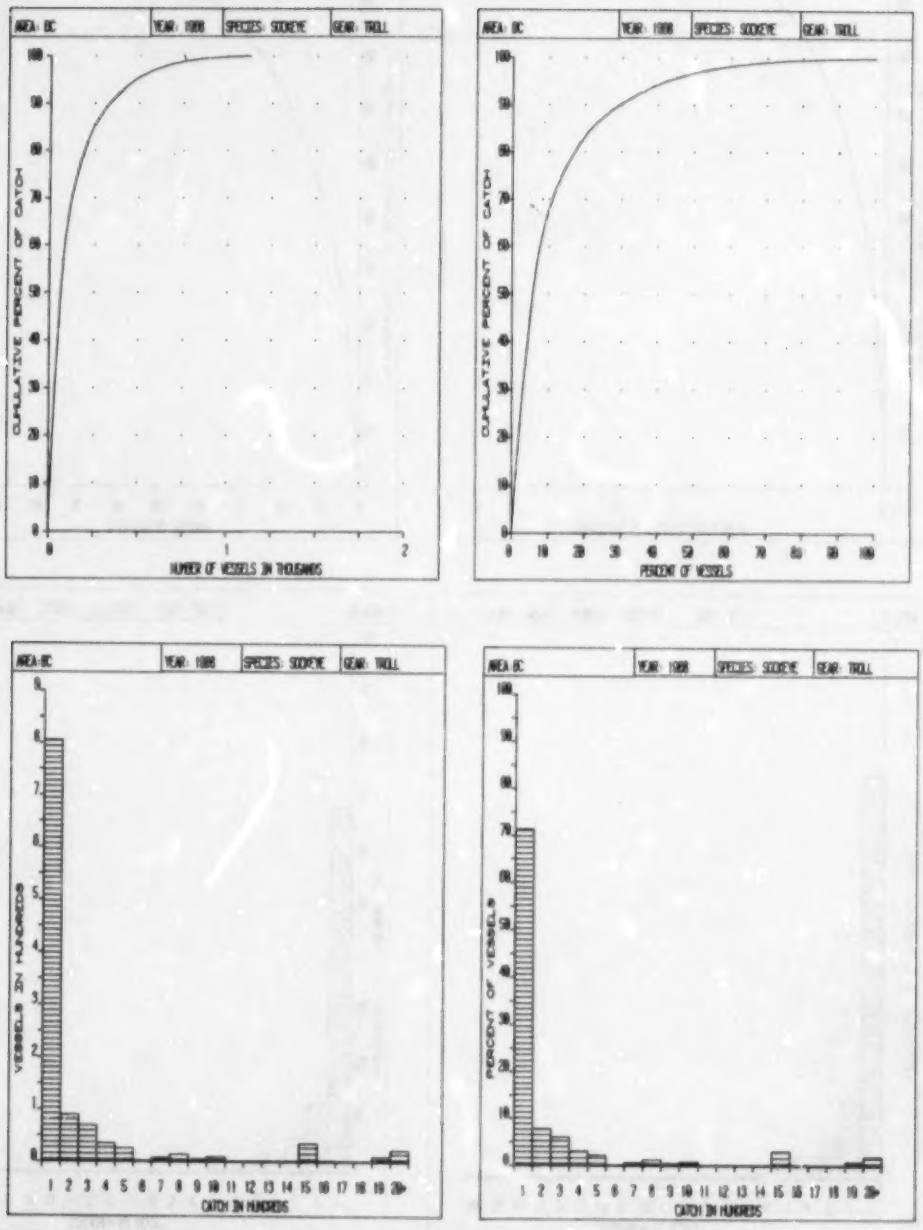

Fig. C2. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1968.

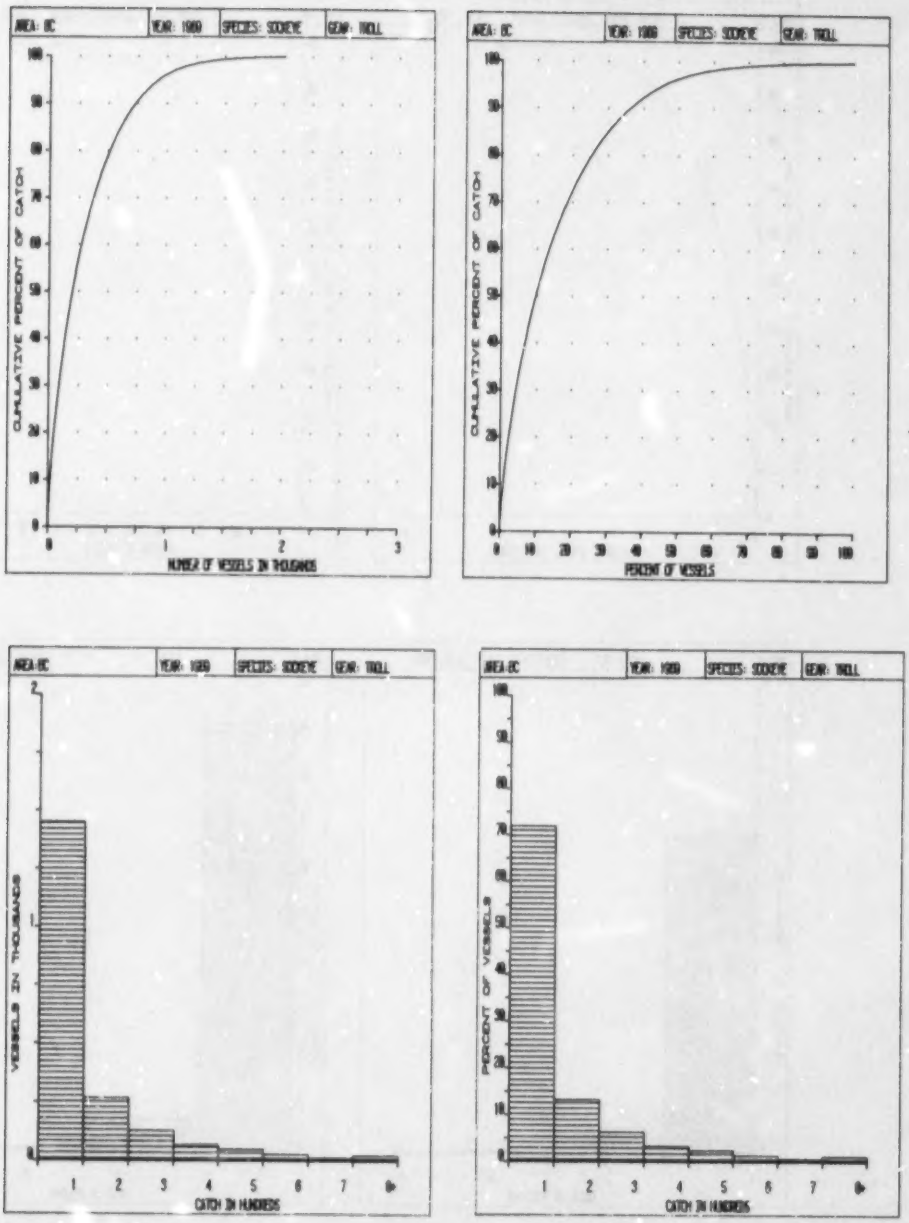

Fig. C3. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1969.

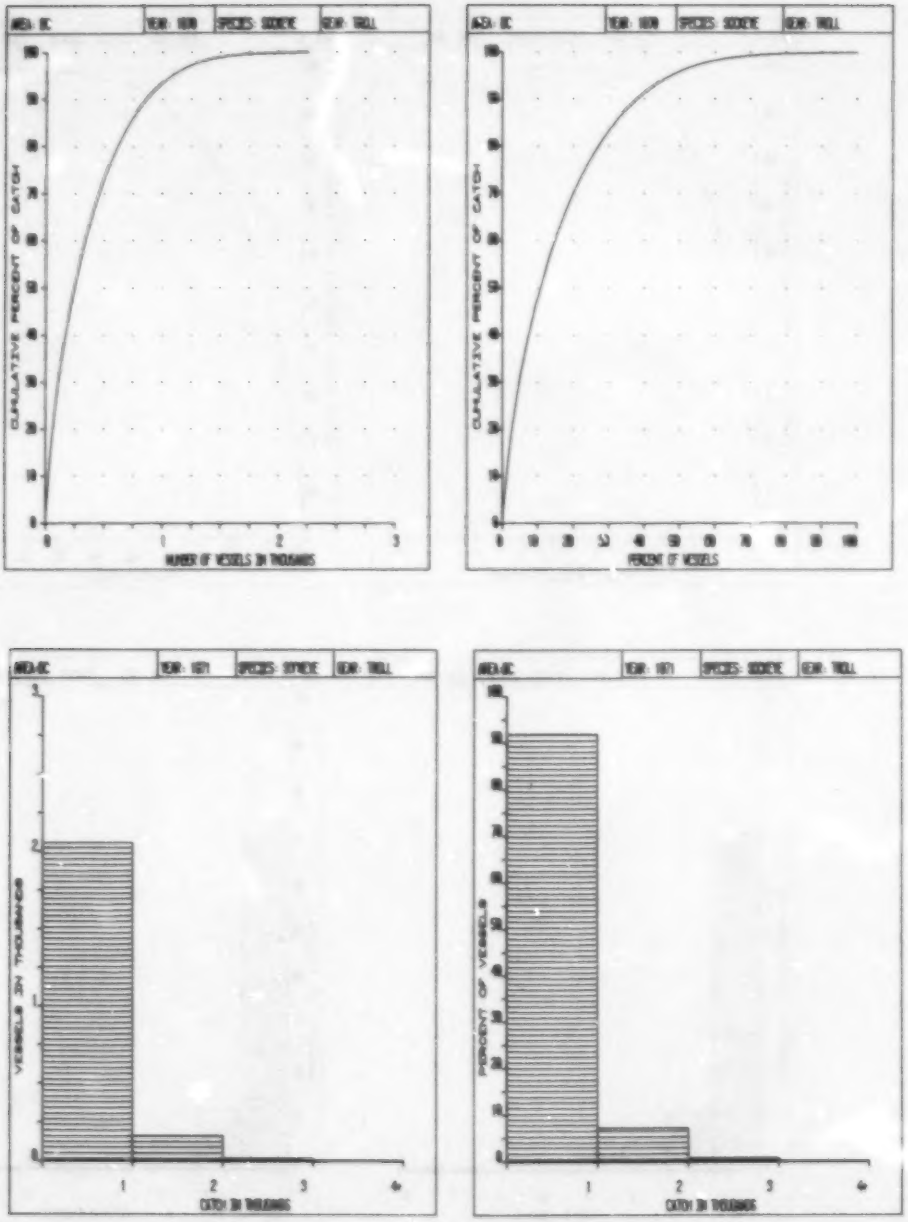

Fig. C4. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1970.

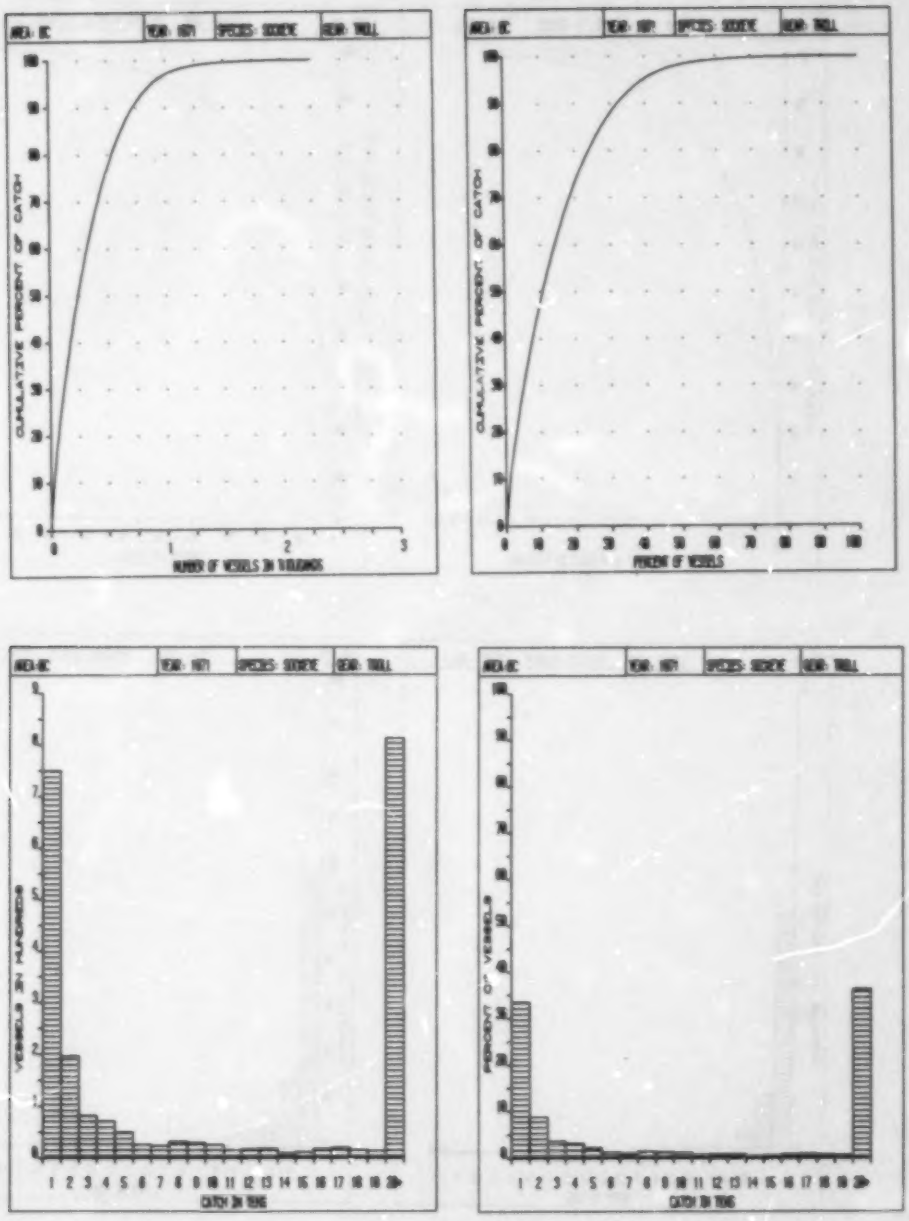

Fig. C5. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1971.

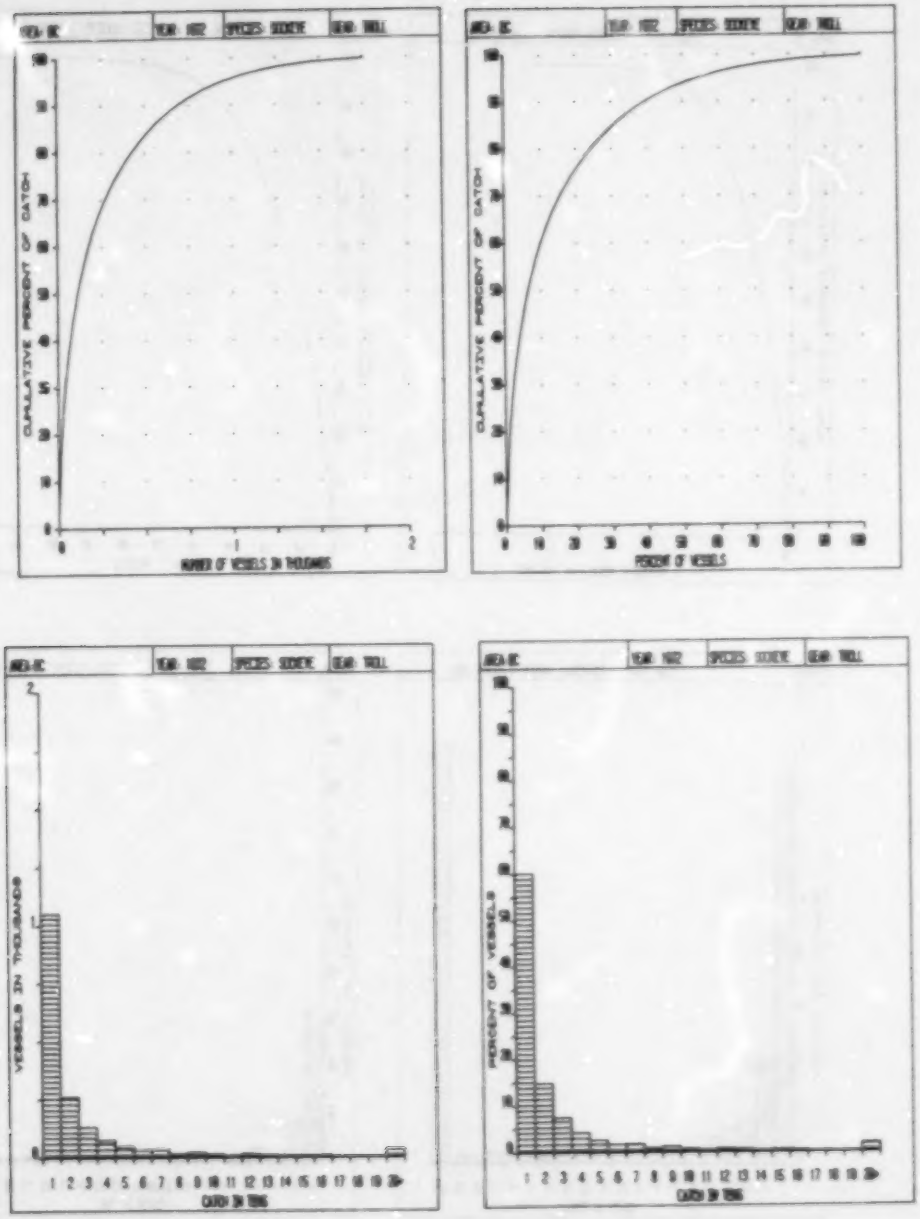

Fig. C6. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1972.

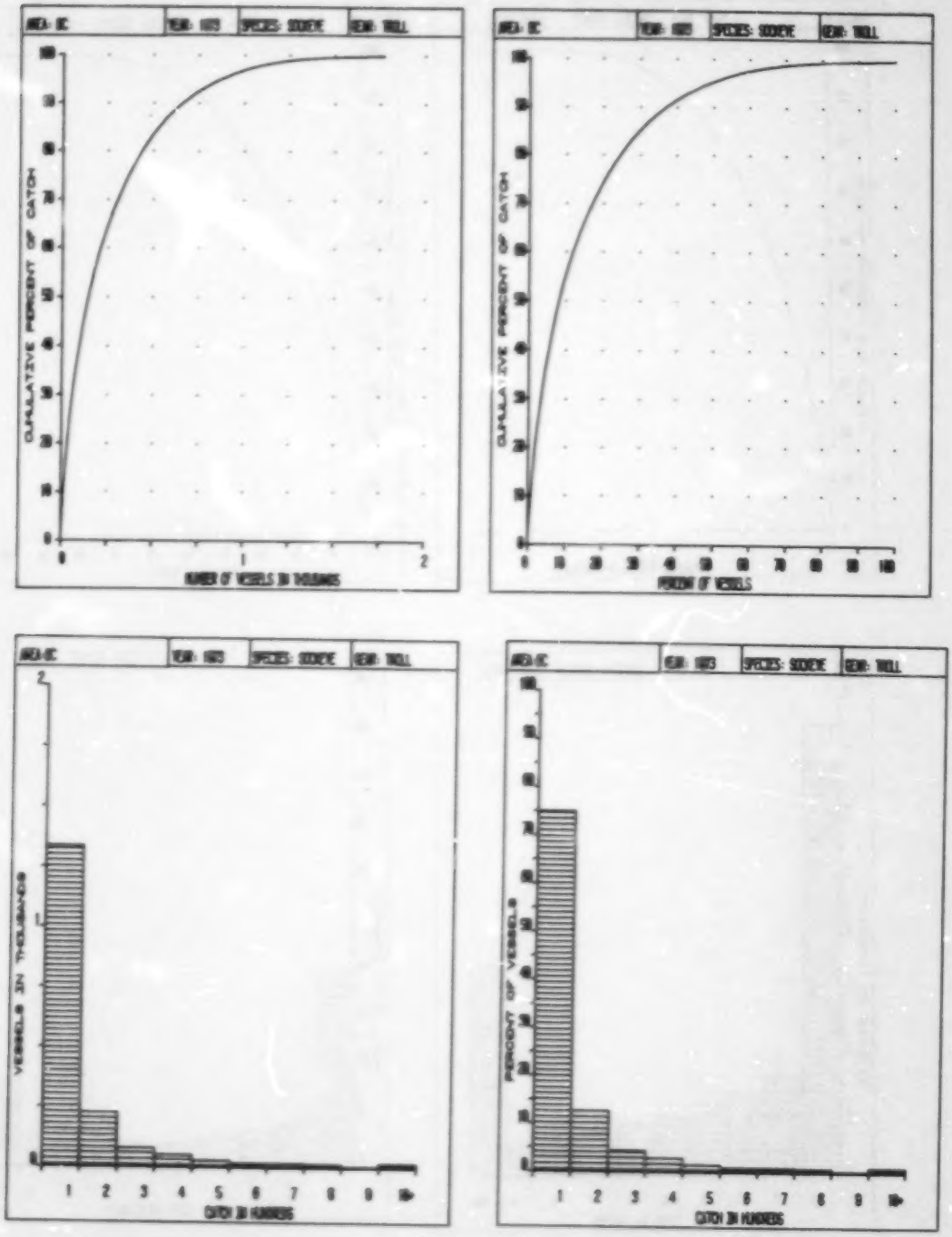

Fig. C7. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1973.

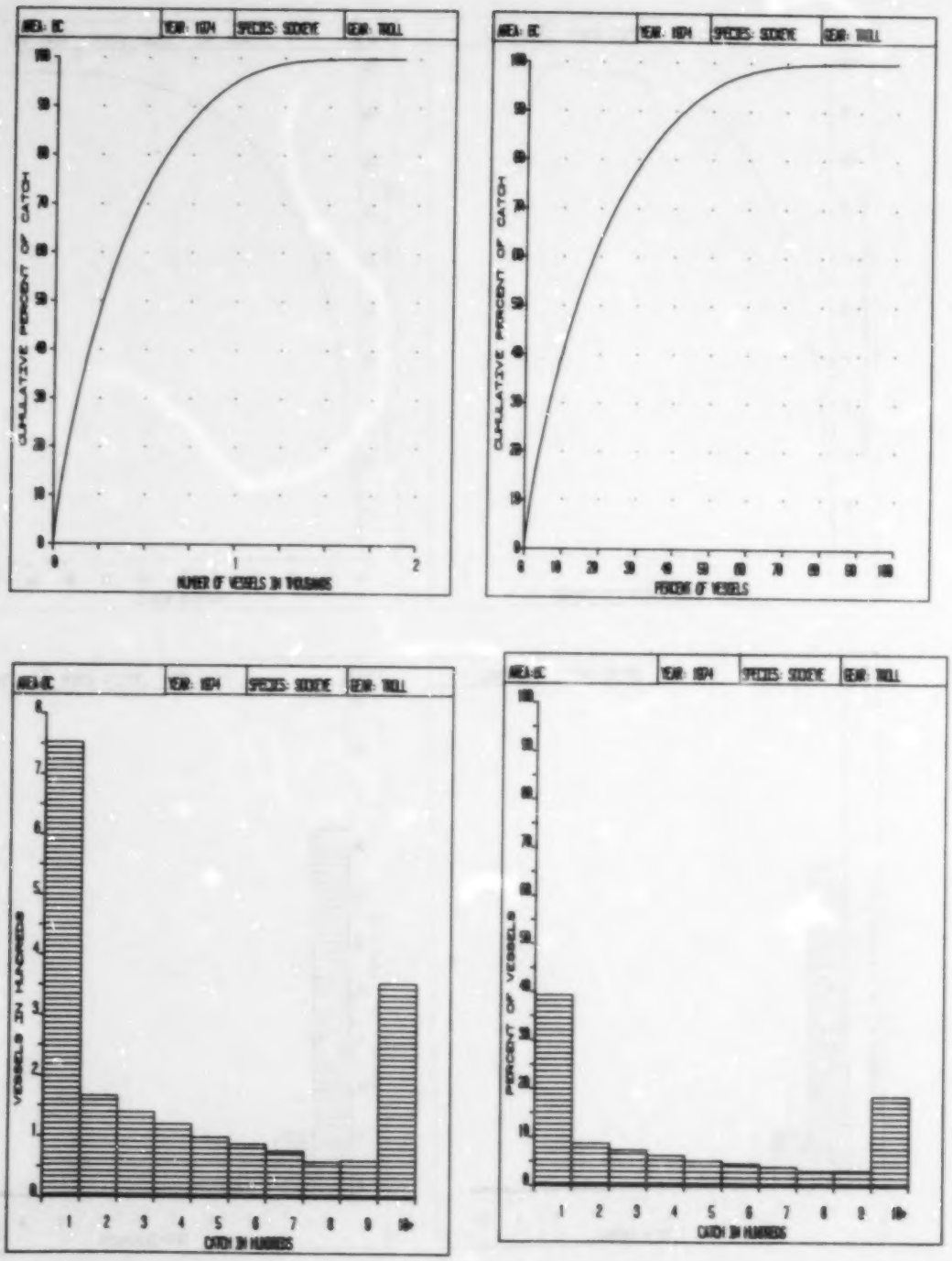

Fig. C8. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1974.

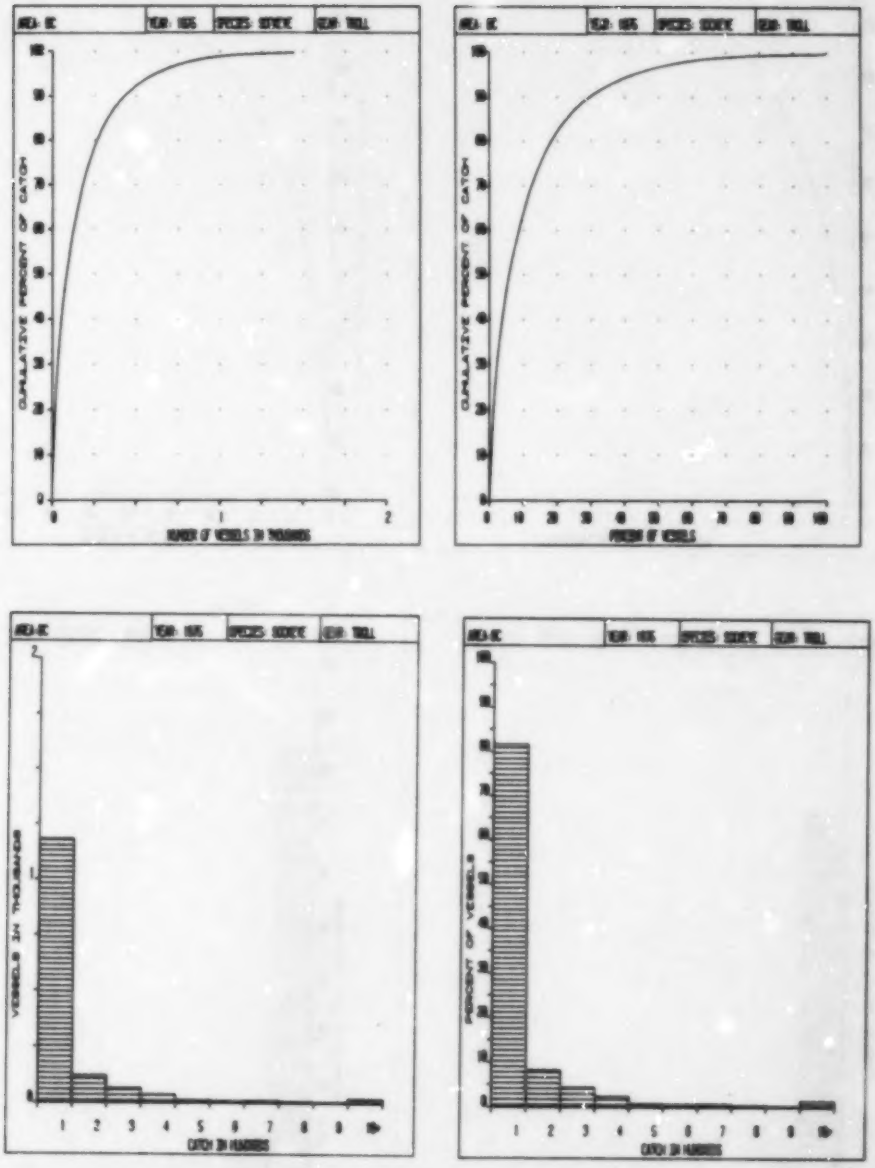

Fig. C9. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1975.

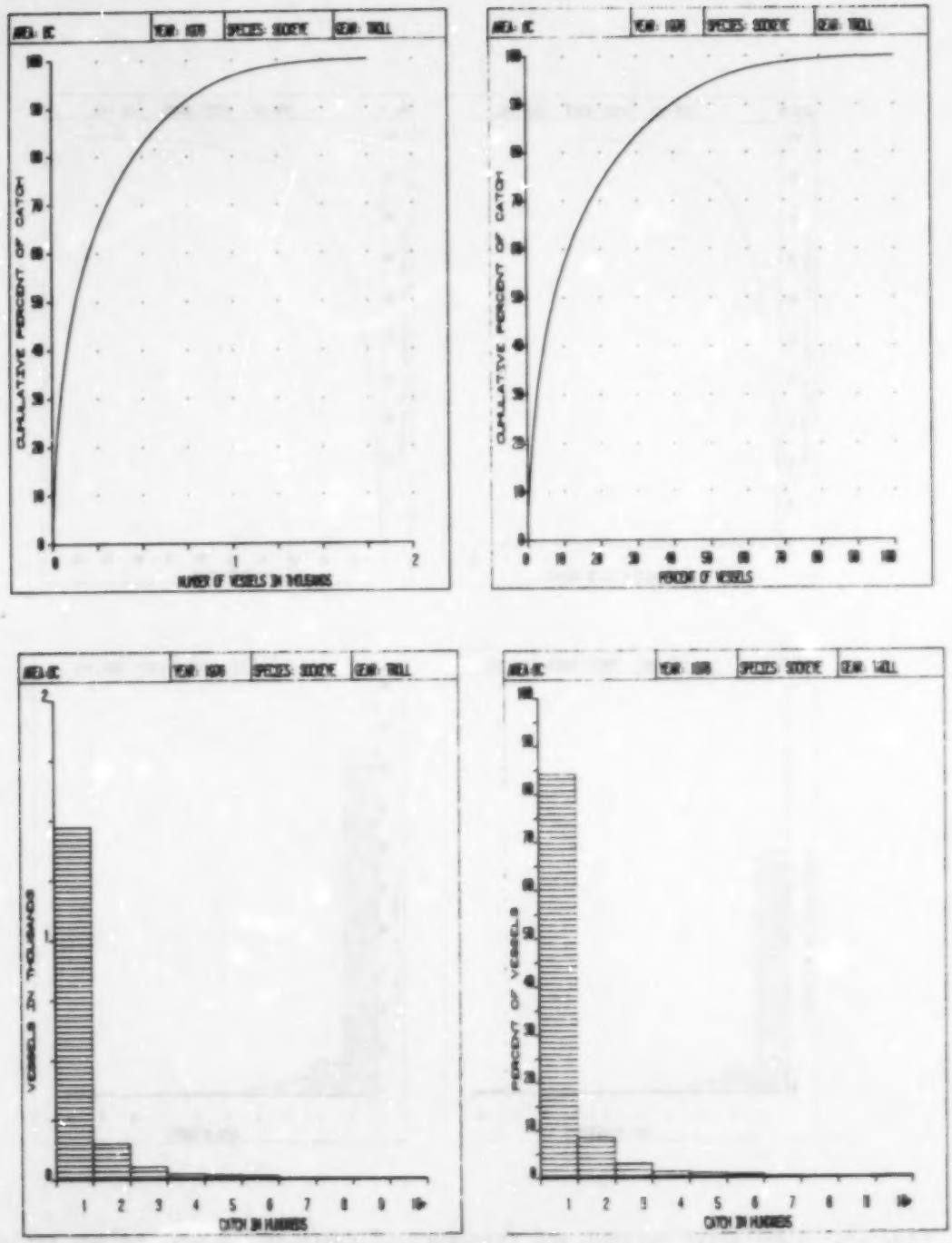

Fig. C10. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1976.

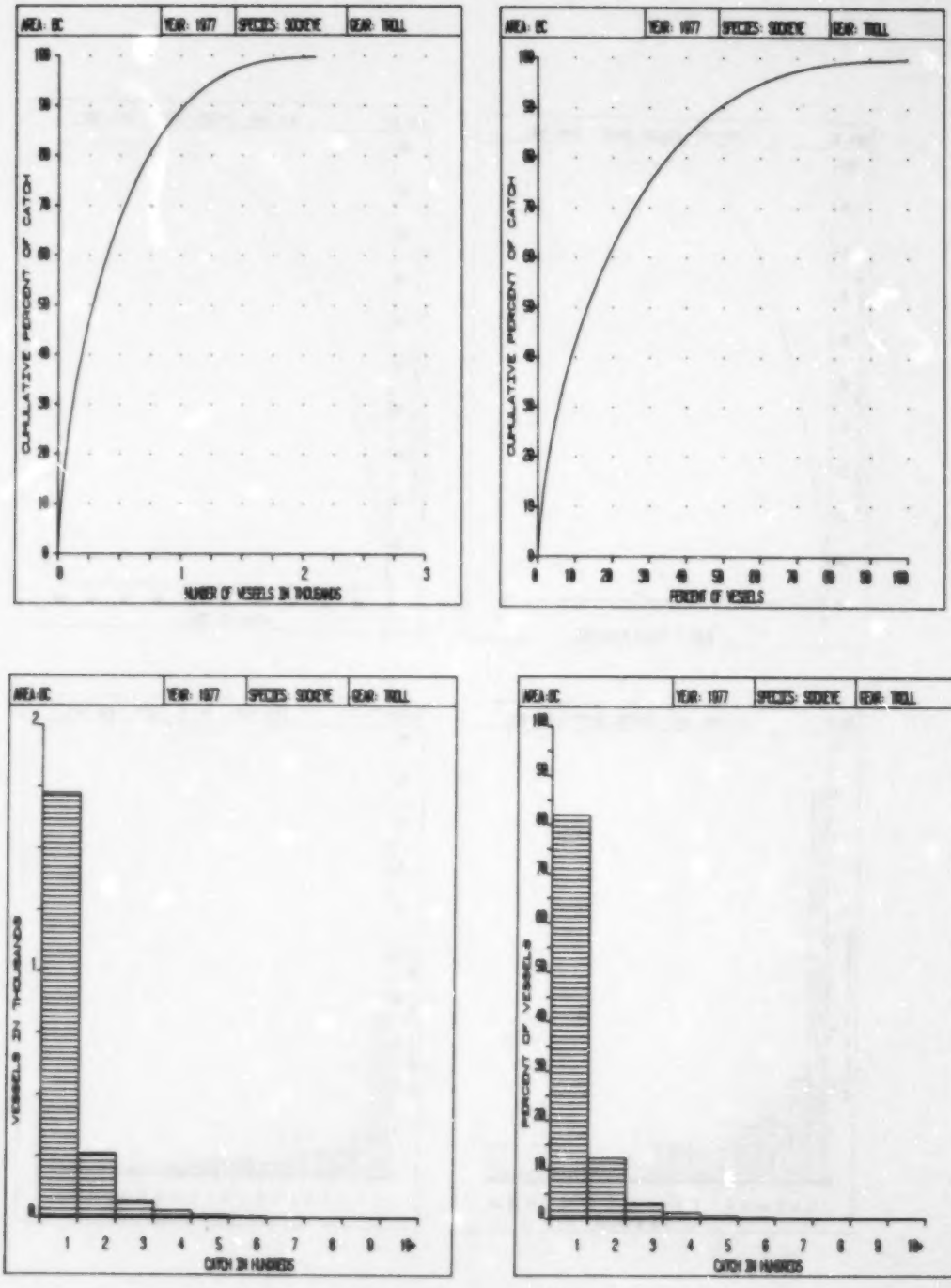

Fig. C11. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1977.

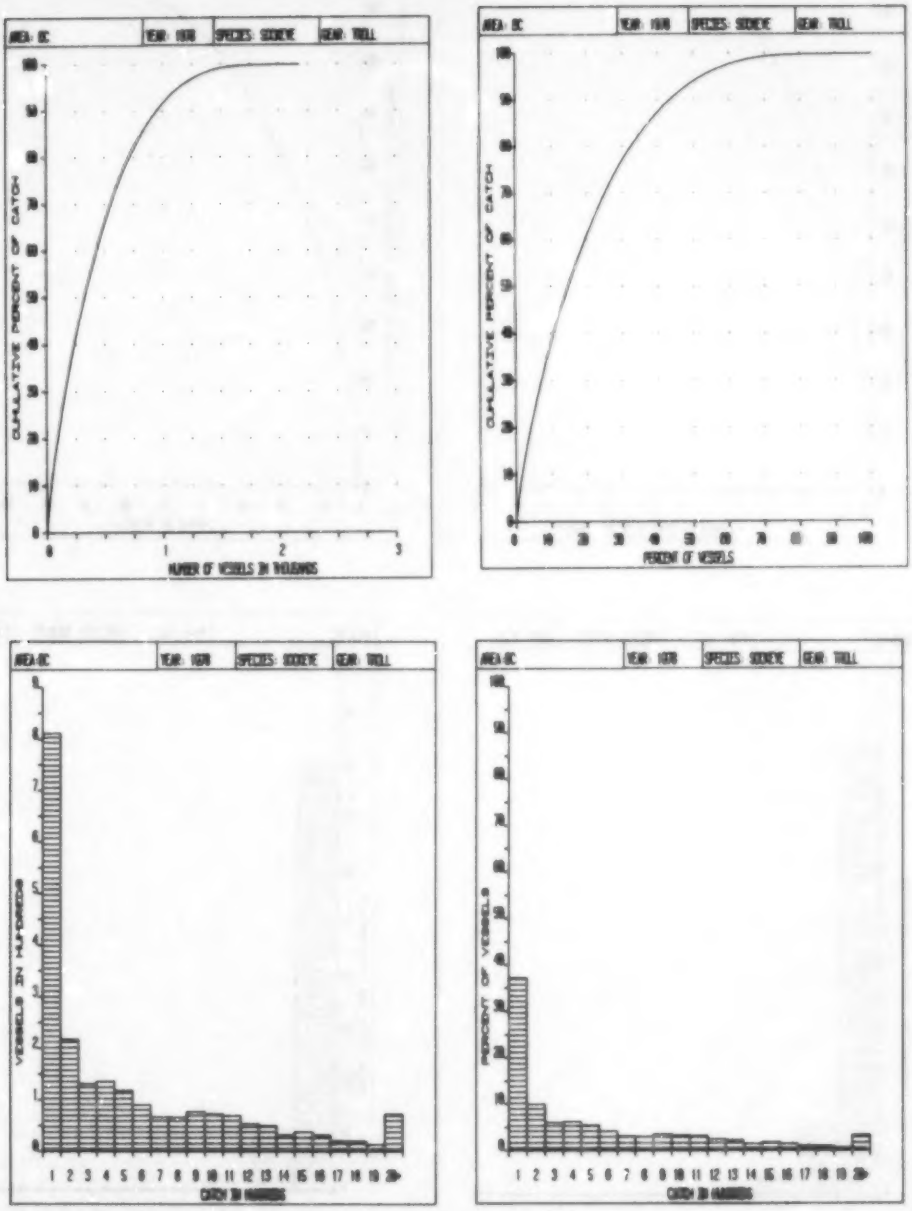

Fig. C12. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1978.

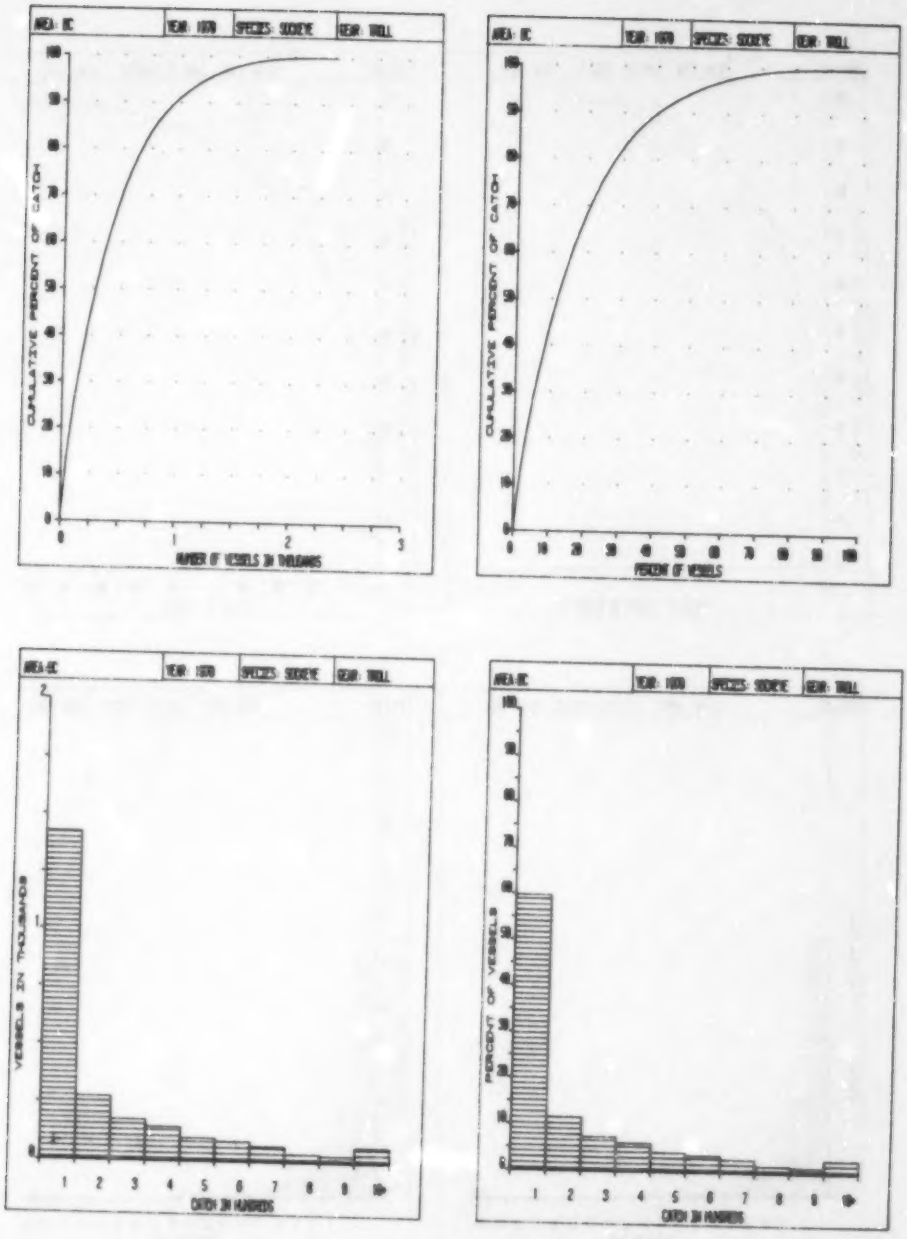

Fig. C13. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll year and participated in the fishery, 1979.

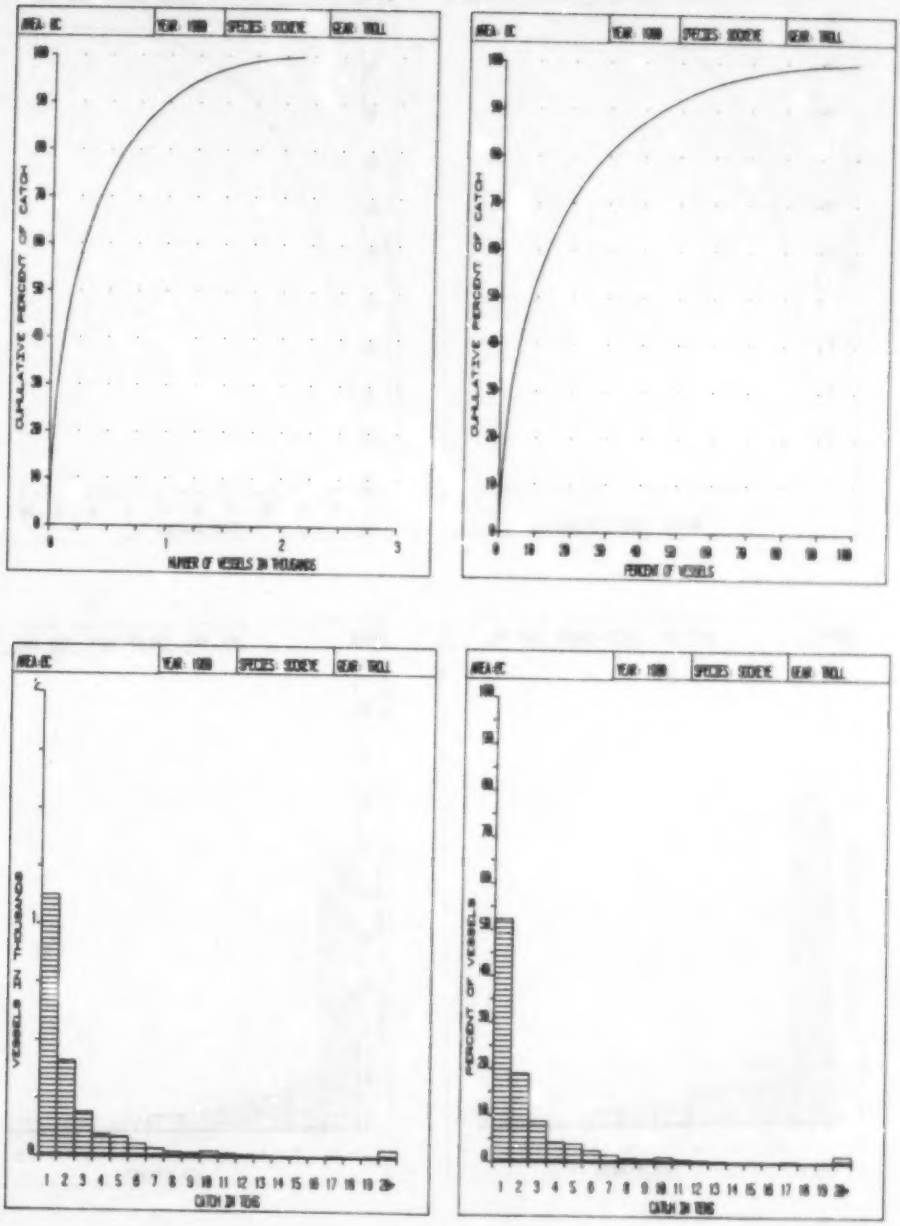

Fig. C14. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1980.

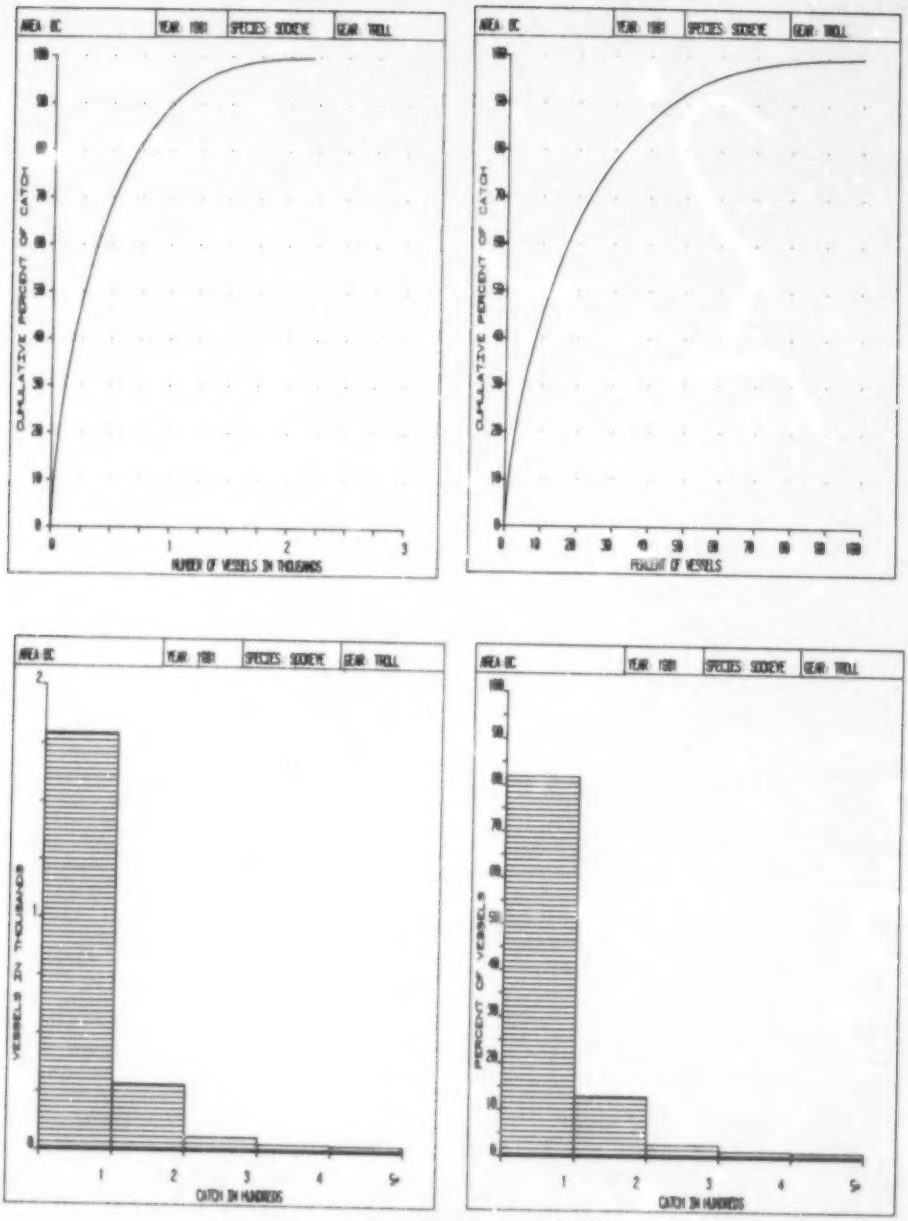

Fig. C15. Cumulative percent and frequency of catch of sockeye salmon versus number and percent of vessels that used troll gear and participated in the fishery, 1981.